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JOURNAL OF DAIRY SCIENCE

VOLUME XVII AUGUST, 1934 NUMBER 8

THE DIFFERENTIATION OF STREPTOCOCCUS LACTIS FROM STREPTOCOCCUS FECALIS

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Ayers and Johnson (1) have shown the great similarity between *Streptococcus lactis* and *Streptococcus fecalis* even when tested by the more modern methods used in the study of streptococci. So much alike are these organisms that it has been questioned whether or not they are in fact identical. Such a view is supported by the work of Demeter (2). Demeter states that the organism known as *Streptococcus lactis* may represent at most only a strain of the fecal streptococcus which frequently assumes a stabilized or habitat form in milk—a possibility suggested also by Ayres and Johnson. Beginning with Kruse (3), a number of older investigators, with less refined methods of differentiation, have believed that these organisms represent only one species.

In addition to general morphological, cultural and fermentative characteristics, the two organisms are similar in their action on blood, their ability to grow at low temperatures (below 10° C.), and in having strong reducing action, evidenced by a sharp reduction of litmus in milk prior to curdling. The one practical test which has served to differentiate the two species is growth at 45° C. At this temperature *Streptococcus lactis* does not grow while *Streptococcus fecalis* does. There is fairly abundant evidence that the maximum temperature for the growth of *Streptococcus lactis* is about 43° C. while the limiting temperature for *Streptococcus fecalis* is around 50° C. (Sherman and Albus, 5; Orla-Jensen, 4; Sherman and Stark, 6.)

It is desirable to know other differences which correlate with the maximum growth temperatures in order to establish more definitely that these organisms represent two distinct species. For this purpose we have studied 27 cultures of *Streptococcus lactis*, isolated originally from milk and milk products, and 14 organisms of the "fecalis group." Of the latter 14 cultures, seven were typical *Streptococcus fecalis* while the other seven were the glycerol fermenting variety to which Orla-Jensen (4) has given the name of *Streptococcus glycerinaceus*. For the purposes of this paper, these two types will be referred to as *Streptococcus fecalis* or as the fecalis group, since they may be differentiated from *Streptococcus lactis* by the same tests.

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The following four tests were found to differentiate perfectly the cultures of *Streptococcus lactis* from those of the *Streptococcus fecalis* group:

(1) *Maximum growth temperatures.* As was to be expected from previous knowledge, none of the lactis cultures was able to grow at 45° C. and their maximum temperatures were found to range from 41 to 43° C. The fecalis cultures all grew vigorously at 45° C. and had maximum temperatures between 48 and 52° C.

(2) *Thermal death rates.* When placed in sterile skimmed milk and heated for 30 minutes at 65° C., all of the lactis cultures were killed while all of those of the fecalis group survived. As would of course be expected, when subjected to lower heat treatments the fecalis group survived in much greater numbers than did the cultures of *Streptococcus lactis.*

(3) *Limiting hydroxyl-ion concentration of growth.* When seeded in poured lactose nutrient agar plates (not streaked) adjusted to varying degrees of alkalinity it was found that *Streptococcus fecalis* is more tolerant to hydroxyl-ion concentration than is *Streptococcus lactis.* At a pH value of 9.6 all of the lactis cultures were entirely inhibited and all of those of the fecalis group grew rapidly. (The sterilized, melted and cooled agar was adjusted to the desided pH immediately before use.)

(4) *Inhibition of growth by sodium chloride.* In poured lactose nutrient agar plate cultures all of the lactis cultures were completely inhibited by 6 per cent NaCl and only three of the 27 cultures were able to grow in the presence of 5.5 per cent of this salt. On the other hand, all of the fecalis cultures grew vigorously in the same medium containing 6.5 per cent NaCl. (In these tests the NaCl was sterilized separately in concentrated solution and added to the melted agar medium before use.)

SUMMARY

Streptococcus lactis may be readily differentiated from *Streptococcus fecalis.*

Streptococcus lactis has a lower maximum growth temperature, a lower thermal death point, a lower alkaline limit for growth, and a lower tolerance for sodium chloride.

Although present conceptions of bacterial species may be profoundly modified as knowledge of dissociation and variation increases, based upon present criteria, there would appear to be ample basis for considering these organisms distinct species.

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IRRADIATED MILK: CHARACTERISTICS OF THE FLOWING FILM REQUIRED FOR OPTIMUM EFFICIENCY OF ANTIRACHITIC ACTIVATION

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Liquid films flowing over smooth surfaces are known to possess certain characteristics which conform to hydraulic principles and which may be designated as possessing smooth or turbulent flowing properties. Data have been obtained correlating the thickness of the milk film, speed of flow and volume of milk delivered per unit of time, with the antirachitic properties resulting from the application of ultra-violet rays of uniform intensity (1) (2). Even though a very large percentage of the radiations are absorbed by the first 0.02 millimeter depth of milk substance it was found that slowly moving films of this thickness were activated to a less degree per unit of time than faster flowing films of greater thickness. It is suggested that the character of the film may have been one of the factors determining these results. According to hydraulic principles the forward movement of each particle or molecule in films with true smooth flow characteristics is maintained, theoretically, in a single plane. In the case of films with turbulent flow characteristics this condition does not hold true, and in such films the particles or molecules, while maintaining the general direction of travel of the film as a whole, are, nevertheless, subject to influences tending to disturb the exact plane of travel, thus causing a degree of agitation or turbulence of the individual particles or molecules. It may be assumed therefore, that films with turbulent flow characteristics permit the exposure of a greater proportion of the milk substance at the air interface surface. Such a condition would seem to be highly desirable for the most effective and efficient antirachitic activation of milk. The data presented in this paper concerns the influence of film characteristics on the efficiency of utilization of the activating energy during the irradiation of milk.

EXPERIMENTAL

It was necessary to obtain data showing the relationship between the amount of milk delivered by given films per unit of time and the thickness of such films. The devices and methods previously described were used for determining the speed of flow, film thickness and distance traveled by

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the film during a given period (1). A curve showing the relationship of film thickness to the amount of milk delivered per unit of horizontal width per unit of time is shown in Chart I. Whole milk at a temperature of

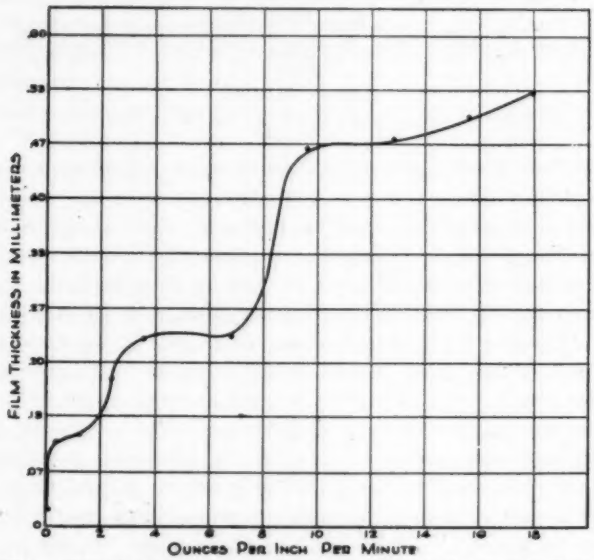

CHART I. THE RELATIONSHIP BETWEEN THE THICKNESS OF THE FLOWING MILK FILM AND FILM CAPACITY

65° F. and containing 3.6 per cent fat was used. The graph shows certain characteristics similar to those obtained from the study of other liquids wherein the transition between dominant smooth and turbulent flow characteristics is recognized by the breaks in the curve. The particular shape of this curve is probably due to the heterogeneous composition and physical characteristics of the milk. The curve indicates that smooth or turbulent flow characteristics are dominant at particular points throughout the range of conditions studied. The marked break in the curve between the film thickness of 0.23 millimeters and 0.46 millimeters is interpreted as the most significant transition range denoting the domination of smooth flow characteristics below 0.23 millimeters, in contradistinction to dominant turbulent flow characteristics in film thickness greater than 0.23 millimeters.

Having determined the relationship between film thickness and film capacity, certain films were duplicated and irradiated with ultra-violet rays of the same character and intensity employed in previous work (1) (2). The particular purpose of this investigation was to ascertain the relationship between film thickness, amount of milk delivered by the film per unit of time, film capacity and the vertical distance of travel necessary to give

a uniform degree of activation. The degree of activation which it was desired to obtain in the milk treated according to the specified conditions was the manifestation of a 2+ degree of calcification (3) (4) from 4 cc. of whole milk containing 3.6 per cent fat, fed daily during a period of 10 days following a 21 day period on the Steenbock rachitogenic diet No. 2965 (5). This degree of antirachitic potency has been shown by Hess and Lewis (6) (7) and Mitchell *et al.* (8) to be valuable in the prevention and cure of infantile rickets. The results are recorded in table 1 and plotted on logarythmic coordinates in Chart II.

TABLE 1

Characteristics of flowing milk films giving the same antirachitic potency when irradiated with the same intensity of ultra-violet radiations

NO.	FILM CAPACITY (OUNCES PER INCH PER MINUTE)	FILM THICKNESS	VERTICAL DISTANCE TRAVELED	EXPOSURE PERIOD
		mm.	*inches*	*secs.*
1	0.075	0.02	0.26	1.00
2	0.310	0.10	1.50	0.75
3	1.200	0.11	11.00	1.30
4	2.400	0.18	——	——
5	3.600	0.23	14.00	1.08
6	6.800	0.23	24.00	1.33
7	9.600	0.46	48.00	2.70
8	12.800	0.47	——	——
9	15.600	0.50	72.00	2.72
10	18.000	0.53	——	——

Inspection of the data, particularly Chart II showing the relationship between the distance of travel of the milk film and film capacity, indicates a definite correlation between film thickness and film capacity on the one hand, and the amount of vitamin D synthesized on the other. While other data have shown a general relationship of this character it is considered that the present results reveal more clearly the significance of the character of the flowing film as it is concerned in the power functions involved in the antirachitic activation of milk. The results are interpreted to mean that under the conditions of irradiation defined by the first part of the curve (Chart II) with uniform slope, the amount of energy applied is in excess of that which may be utilized most efficiently for activating the specified amount of milk to the particular degree selected as the criterion for these tests. The time necessary to bring about the specified degree of activation within the particular range of film thicknesses and film capacities may therefore, be considered as the irreducible minimum. Throughout the range of conditions represented by the flat portion of the curve the capacity of the film increases without substantial increase in film thickness. Since the

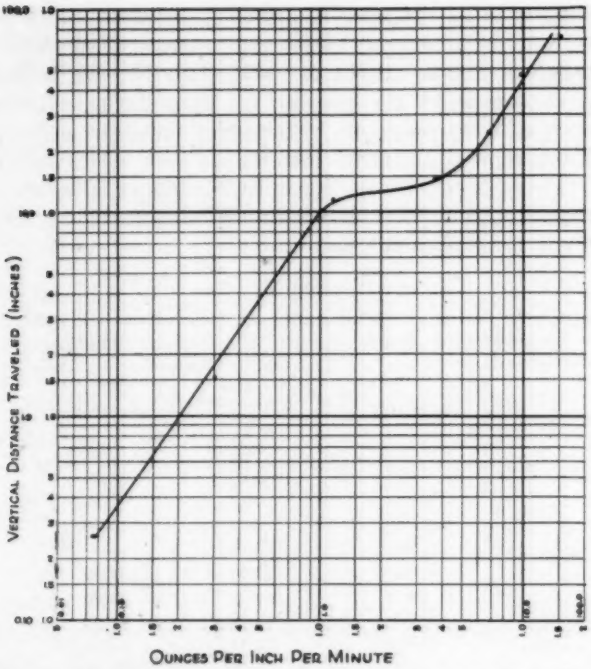

CHART II. THE RELATIONSHIP BETWEEN THE CAPACITY OF THE FLOWING MILK FILM AND DISTANCE OF TRAVEL NECESSARY TO GIVE A UNIFORM DEGREE OF ANTIRACHITIC ACTIVATION

degree of activation throughout this range is the same as for other conditions, the break in the curve is interpreted to mean that the applied energy is being used more efficiently than under any of the other conditions studied. It is believed that this greater efficiency in utilization of the applied radiations is caused primarily by the particular characteristics of the flowing film, whereby the correlation between vertical distance of travel, surface exposure of activable substances and film capacity are interrelated in a manner providing optimum conditions for activation within a minimum period of time. It is to be noted that in the upper part of the curve where a straight line of uniform slope has again been established by relatively thick films, which however, do not increase in thickness at a rate commensurate with the increase in film capacity, the time of exposure required to produce the specified degree of activation is about twice that required under optimum conditions. The films of higher capacities are believed to have predominately turbulent flow characteristics. However, from the standpoint of maintaining all conditions at their optimum, such films are less desirable

than the somewhat thinner films. Nevertheless the thick films are materially more desirable from a practical point of view than the very thin films of low capacity and less dominant turbulent flow characteristics.

CONCLUSIONS

1. The flow of milk films over smooth vertical surfaces by gravity can be differentiated as films with dominant smooth flow characteristics, or dominant turbulent flow characteristics.

2. Milk may be activated to a 2+ degree of calcification, as determined by standard assay procedures under a wide range of properly coordinated conditions involving film capacity, film thickness and distance of film travel, within a momentary period of exposure. There are certain optimum conditions wherein the applied energy is utilized more effectively and efficiently; such conditions are determined by the relationship between film thickness and film capacity.

3. Results indicate that the irreducible minimum in time necessary to give the specified degree of activation desired in these experiments was from 0.75 to 1.30 seconds. Exposure periods of 2.70 seconds gave the same degree of activation under conditions which permitted a marked increase in the amount of milk which could be activated per unit of time.

The authors acknowledge the assistance rendered by G. E. Flanigan, M. R. Simonds, Dr. R. C. Bender and Dr. Stefan Ansbacher, of the Dry Milk Company Research Laboratory Staff, during the collection of data contained in this report.

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SOME PHYSICO-CHEMICAL PROPERTIES OF LACTOSE

II. FACTORS INFLUENCING THE CRYSTALLINE HABIT OF LACTOSE

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INTRODUCTION

Photographs, or sketches of lactose crystals have been published by a number of men. All are assumed to be alpha hydrate, yet on casual inspection, some of the crystals seem quite different from others. That lactose solutions do yield crystals of quite different appearance, depending upon conditions of crystallization, may be confirmed by microscopic examination. This fact seemed worthy of further investigation for several reasons. It seemed possible that some of the strange crystals might not be alpha hydrate at all. Beta hydrate has never been isolated and recognized, nevertheless, it might appear as an unstable phase under certain conditions; and since a molecular compound of alpha and beta lactose has been prepared (5), others might exist.

The first problem, therefore, was to establish the identity of the various crystals, and to determine the relation between the different forms. If all proved to be alpha hydrate, then the second problem would be to determine what factor, or factors, is responsible for such striking differences in crystal habit. If the factors responsible for the appearance of different forms were known, then it might be possible to examine the crystals in such products as sweetened condensed milk, or sandy ice cream, and learn something about the conditions under which the crystals were formed.

Hunziker and Nisson (6, 7) reported that sucrose modified the form of lactose crystals. Williams and Peter (15) reported a similar observation. It is well known that the crystalline habit of many substances may be altered by the presence of other compounds. Saylor (11) has given a good discussion of the theory of this phenomenon. It is due to selective adsorption on certain faces of the crystal. The possibility of such an adsorption of sucrose by lactose seemed worthy of investigation because of its application to the crystallization of lactose in ice cream and in sweetened condensed milk.

In order to answer some of these questions, crystals of lactose were allowed to form under various conditions, and in the presence of various added substances. The shape of these crystals was studied carefully. The

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relation between the different crystalline types was determined as far as possible, and an attempt was made to correlate the type of crystal with the conditions under which crystallization took place. This paper is a summary of the observations which were made during these investigations.

EXPERIMENTS

Crystals were prepared for examination by placing drops of supersaturated lactose solution upon microscope slides and then protecting them from evaporation by means of cover slips sealed down with a mixture of vaseline and beeswax. These slides were held at a constant temperature for several days before examination. Photographs of several well developed crystals of alpha hydrate prepared in this manner are shown in figure 3.

The diagram of a lactose crystal given by Groth (4) shows ten faces. This diagram is also given by Hunziker and Nisson (7) who state that the fully developed lactose crystal has ten faces. However, if crystals are grown very carefully, at least sixteen faces may be found. Some of the crystals shown in figure 3 have thirteen faces. In their own paper, Hunziker and Nisson published photographs showing faces not included among the ten. Crystals having more than 13 faces are extremely rare, but the new faces are of interest because they appear on some crystal types of frequent occurrence.

In addition to studying crystals grown on microscope slides, examinations were made of crystals grown in test-tubes, in ice cream, in sweetened condensed milk, in agar and in gelatine jellies, and in other ways. Figures 2 and 3 show some of the characteristic crystal types which were found. All of these crystals proved to be alpha hydrate.

The relationship of the different forms to one another might be shown by either of two methods: first, by studying a large number of crystals and tracing the gradual transition from one type to another; and second, by so altering conditions during crystallization that one form of crystal would change over to another form while the crystal was under constant observation. Both methods were used in this study.

Although Sato (10), and Hunziker and Nisson (6, 7), described pyramidal shape as being characteristic of lactose crystals grown in sucrose solutions, it was found that pyramidal crystals may be grown in the absence of sucrose, and that normal lactose crystals may be grown in the presence of large amounts of sucrose. Cane sugar has no specific action upon the crystalline habit of lactose. A study of crystals produced by cooling, by evaporation, and by precipitation by alcohol, led to the conclusion that the rate of growth, or what might be termed the "crystallization pressure," was the principal factor determining the form of the crystals.

When the crystallization of lactose is forced rapidly enough, only prisms are formed. As the precipitation pressure becomes less the prisms become

shorter and broader. With further decrease, the crystals appear first as diamond-shaped plates. These have been observed by Williams and Peter (15). These diamonds form the base of the pyramidal crystals of Sato, and of Hunziker and Nisson. At slightly lower degrees of supersaturation, these plates grow in thickness forming pyramids. Crystals appearing in more dilute solutions lie on a different face, and appear as triangular plates having two sides equal. This is the outline of the ordinary "tomahawk." As crystallization proceeds slowly, the crystals increase in thickness, and bevel faces appear on the short side of the triangle, thus sharpening the blade of the tomahawk. At a later stage, it becomes apparent that the apex of the triangle is not a point, or a line, but a surface. Still later, another pair of bevel faces appear, completing the set of ten faces described by most authors. Figure 1 shows sketches illustrating this gradual transition. Photographs of these various forms have already been referred to in figure 2.

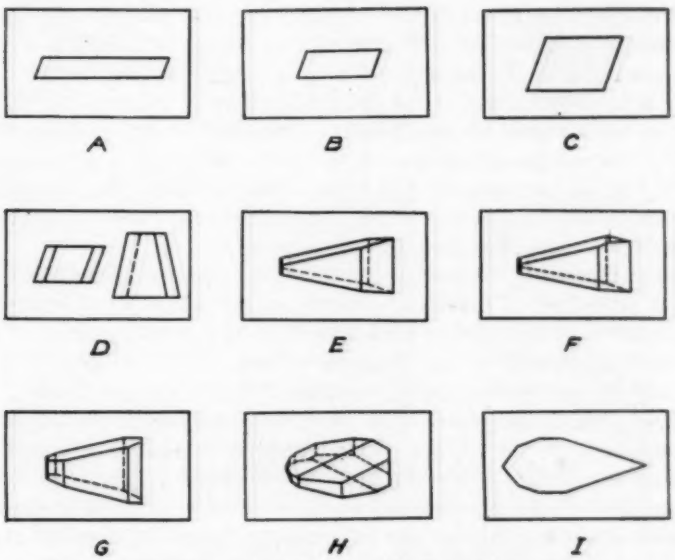

FIG. 1. THE CRYSTALLINE HABIT OF LACTOSE ALPHA HYDRATE

A. Prism, formed when velocity of growth is very high.
B. Prism, formed more slowly than prism A.
C. Diamond shaped plates, transition between prism and pyramid.
D. Pyramids resulting from increase in thickness of diamond.
E. Tomahawk, a tall pyramid with bevel faces at the base.
F. Tomahawk, showing another face which sometimes appears.
G. The form most commonly described as "fully developed."
H. A crystal having 13 faces. The face shown in F is not present.
I. A profile view of H with the tomahawk blade sharpened.

If crystallization takes place very slowly, other faces may be observed. The small surface at the apex of the crystal becomes two surfaces. These faces may be found in some of the photographs published by Hunziker and Nisson (7). Later two additional faces may appear running obliquely along the crystals. Their position is shown in figures 1–H and 3–A. Finally, another pair of parallel faces may appear cutting off the corners of the hatchet blade, figures 1–F and 3–E.

Different combinations of these many faces produce a great variety of crystal forms which, at first glance, seem to bear no resemblance to each other. However, if the fundamental relationship between the faces is understood, such crystals may usually be recognized without difficulty.

The relationship between the different crystal types illustrated in figures 1, 2 and 3 may be traced out by the examination of a large number of crystals showing the transition from one form to the other by almost imperceptible degrees. This relationship may also be shown more directly by observing changes in the growth of a single crystal when the conditions of crystallization are altered. Tomahawk crystals can be formed in a drop of lactose solution on a microscope slide, and then, when evaporation is hastened, by means of a current of air, the tomahawks will grow in width becoming "broad axes" or even prisms. This is illustrated in figure 2–H.

The reverse phenomenon may also be observed, lactose precipitated quickly by alcohol separates first in the form of prisms, but as crystallization slows down, the prisms become wider and tend to revert toward the "broad axe" or the tomahawk form, figure 2–G.

An examination of lactose crystals indicates that they have only a single axis of symmetry. This has been confirmed by Elings and Terpstra (2), and it offers an explanation for a phenomenon that was puzzling. When dehydrated lactose is removed from the drying oven for weighing, the crystals adhere together resembling wet sand. Alpha anhydride has a great affinity for water, and it seemed that traces of moisture were responsible for this effect. However, all precautions failed to prevent this apparent absorption of moisture by such samples before weighing, and it was finally discovered that the phenomenon was due to an entirely different cause. Crystals possessing only an axis of symmetry become electrically charged at the poles when they experience a change in temperature (12, also 13, volume 2, p. 1393). These charges are responsible for the coherence of the lactose crystals, for their apparent dampness after their removal from a drying oven. Partially dehydrated lactose in an evacuated and sealed tube exhibited this phenomenon, either when warmed over a flame, or when chilled in a freezing mixture, proving that surface moisture was not the cause of the apparent dampness. Since completely dehydrated alpha lactose shows the same behavior, it appears that alpha anhydride crystals must also possess only one axis of symmetry.

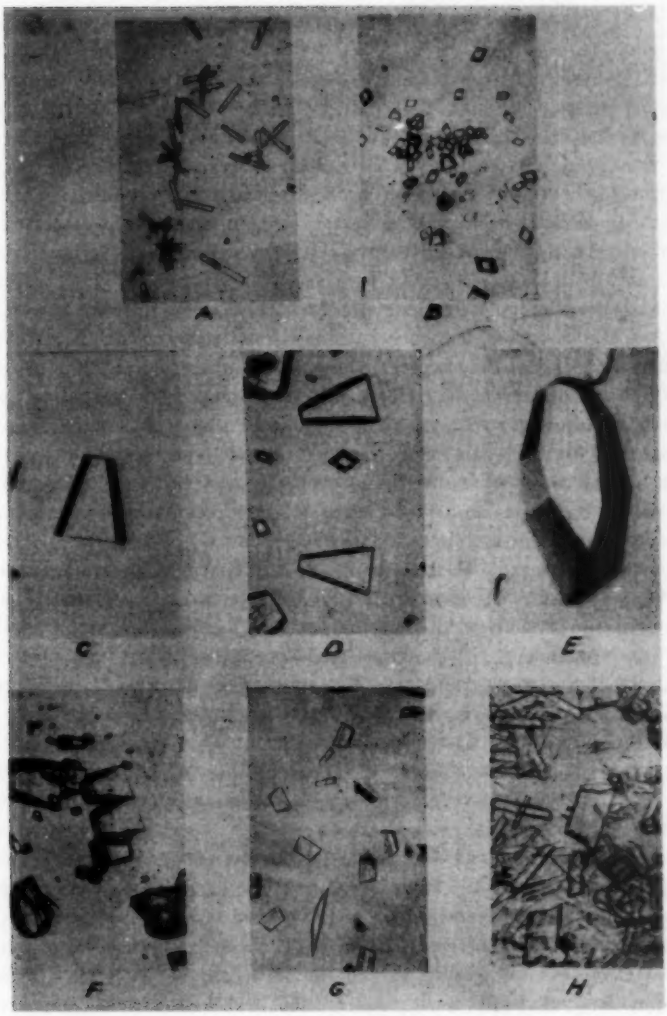

FIG. 2. PHOTOGRAPHS OF LACTOSE CRYSTALS

A. Prism form. Compare with Figure 1–A.
B. Diamond form. Compare with Figures 1–C and 1–D.
C. Pyramids. Compare with Figure 1–D.
D. Tomahawk form. Compare with Figure 1–E.
E. The form usually described as "fully developed."
F. The broadaxe form. A shortened tomahawk.
G. Lactose prisms transferred to a solution only slightly supersaturated with lactose. The prisms are reverting to the tomahawk form through the broadaxe stage.
H. Crystals formed by the evaporation of a drop of lactose solution. A few seconds earlier, the large crystal in the center was a well formed tomahawk. Rapid evaporation is resulting in the formation of prisms.

The formation of crystal clusters takes place more readily when the precipitation pressure is high, but the effect of precipitation pressure upon cluster formation is not as clear cut as its effect upon the form of the crystals. Other factors must influence cluster formation because the clusters often develop when the degree of supersaturation is very low. In spite of the greatest care, it has not been possible to grow lactose crystals to sizes greater than a half gram without having branch crystals appear on the surfaces.

One observation regarding cluster formation seems worthy of mention. Whenever a new crystal appears as an outgrowth of another, it always has the blade of the tomahawk directed away from the parent crystal. The apex of the second crystal is always directed toward the first. No exception to this rule was ever found although more than a hundred cases were examined. This seems the more remarkable since the second crystal may appear at any point upon the surface of the first (although they usually appear near the apex) and since there seems to be no definite orientation of the axes of the two crystals.

Mention has already been made of the fact that sucrose is said to cause lactose to crystallize as pyramids. While such crystals are often formed in the presence of sucrose, the sucrose has no specific action upon the crystallization of lactose. Highly developed crystals of lactose may be grown in concentrated sucrose solutions, and pyramidal crystals may be grown from solutions of lactose in pure water. What influence sucrose may have is probably due to its influence upon the rate of crystallization, by increasing the viscosity, and by lowering the solubility of lactose. Peter (9) found that the solubility of lactose at 0° C. was reduced nearly one-half by saturating its solutions with sucrose.

There has been considerable debate, by a number of workers, concerning the effect of foreign substances upon the crystallization of lactose. Leighton and Peter (8) and Fujimoto (3) have studied the effect of dyes. No significant action was found. There seems no reason why dyes should influence crystallization unless they are adsorbed by the crystals. Such an adsorption of dyes should easily be detected if it occurred, but neither author mentions any staining of the crystals. Fujimoto believed that both gelatine and sucrose inhibited the crystallization of lactose. On the other hand, Dahle (1) believed that other sugars had no influence upon the crystallization of lactose, and that gelatine had practically no effect. Dahle also reported that rennet coagulation had no influence. Hunziker and Nisson (6) reported that the colloids of milk had no influence upon either the crystal form of lactose, or upon its solubility.

It is not always easy to distinguish between the specific effect of added substances, and the effect of crystallization velocity, upon the crystalline form of lactose. Most studies on the crystallization of lactose have failed

to distinguish between the rates of nuclei formation and the rates of crystal growth. The rate of nuclei formation may be influenced by many factors, and most of those who have studied the crystallization of lactose in ice cream have not taken this into account. Moreover, experiments on the rate of crystal growth have little value unless the number of nuclei present is controlled. For these reasons, it is not surprising that there should be such disagreement regarding the effect of foreign substances upon lactose crystallization.

Some experiments were carried out to determine the effect of a few substances upon the crystallization of lactose. In order to exaggerate any possible action, the foreign substance was added in relatively large amounts. Thirty-five grams of dextrin, of sucrose, or of gum arabic, added to 100 cc. of a solution of lactose saturated at 60° C., seemed to have no definite influence upon the crystallization of lactose. A similar quantity of gelatin caused the formation of dense clusters of crystals resembling those formed by an aqueous solution of lactose saturated at 80° C., when it was allowed to crystallize at 0° C. Starch seemed to act similarly but observation was practically impossible because of the opacity. Molar concentrations of urea, of ammonium chloride, of sodium acetate, and of potassium chloride seemed to have no specific effect upon crystallization. The action of salts, however, will be considered again in papers five and six. These results are not to be considered as conclusive evidence that the substances mentioned have no effect. However, in dilute solution any action which they may have will be slight. On the other hand, preliminary experiments have indicated that beta lactose does retard the crystallization of alpha hydrate. However, this phenomenon must be investigated more thoroughly before it is finally accepted.

The solubility of lactose is greatly reduced by the presence of alcohol. Additions of alcohol, therefore, accelerate the crystallization of lactose and thus indirectly influence the crystal habit to a marked degree. The addition of alcohol to cold saturated solutions of lactose results in another interesting phenomenon. When the alcohol is added to the sugar solution, the mixture becomes milky white for a few seconds, and then clears up again. After a few minutes, a permanent precipitate of lactose crystals will appear. Microscopic examination proved that the formation of an emulsion was responsible for the transitory milkiness. This is of interest because alcohol and water are miscible in all proportions. Presumably, some solid phase is precipitated in the interface, but its nature is as yet unknown. If it were alpha hydrate, there seems no reason why it should apparently dissolve again, yet often there is a lag of several minutes between the time of clearing and the time when the visible crystallization of lactose takes place.

Wherry (14) has published crystallographic data regarding beta lac-

tose. No attempt was made to study in detail the variation of the crystalline habit of this sugar with changes in conditions. However, it was observed that beta lactose also forms prisms when crystallization is sufficiently rapid. The prisms of beta lactose may be distinguished from those of alpha hydrate by the fact that they are curved, figure 3–H. They may be prepared by dissolving beta lactose in ice-water and then precipitating with alcohol, or by the crystallization of such a solution at low temperatures by rapid evaporation. The curved needles may also be found in the precipitate formed by adding alcohol to equilibrium solutions of lactose.

SUMMARY

The crystalline habit of alpha hydrate varies greatly under different condition of crystallization.

The relationship between the different types of crystals was traced: first, by examining many crystals varying by imperceptible degrees from one another; and second, by changing conditions during crystallization, thereby causing crystals to develop new faces and to alter their habit of growth.

The principal factor governing the crystalline habit of lactose is the precipitation pressure, the ratio of the actual concentration to the solubility. By varying this ratio, a great variety of crystal types may be produced.

The influence of sucrose upon the crystalline form of lactose is not a specific action but is due to its precipitating effect upon that sugar.

Both alpha hydrate and beta anhydride will form needles if crystallization is sufficiently rapid. The two may be distinguished readily by the fact that the prisms of alpha hydrate are always straight while those of beta anhydride are curved.

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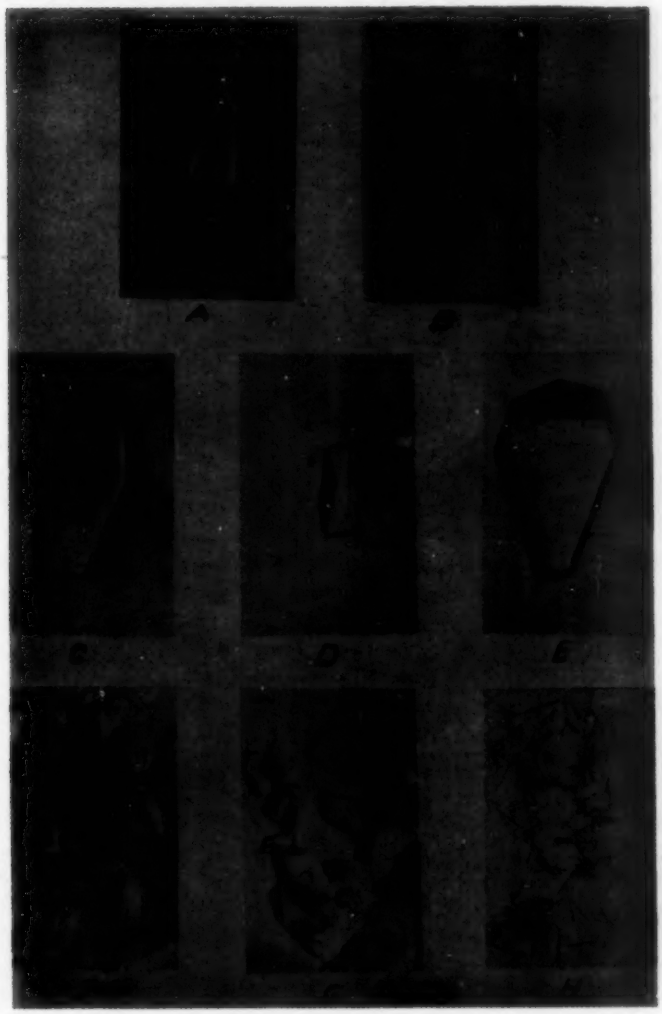

FIG. 3. PHOTOGRAPHS OF LACTOSE CRYSTALS

A, B, C, and D. Lactose crystals having 13 faces. Compare with Figure 1–H.
E. A lactose crystal lying on the face shown in Figure 1–F. Here it is a major face. Compare also with Figure 1–I.
F. Crystals found in a commercial preparation of lactose alpha hydrate.
G. Crystals found in a commercial preparation of beta lactose.
H. Curved needle crystals of beta lactose.

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THE RELATION BETWEEN THE HARDNESS OF BUTTER AND BUTTERFAT AND THE IODINE NUMBER OF THE BUTTERFAT*

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Considerable data have been secured at the University of Minnesota concerning the relation between the chemical constants of butterfat and the hardness of the butterfat and butter. This has been one of the problems encountered in studies of the effect of various feeds on the character of butterfat.

METHOD OF DETERMINING HARDNESS

Numerous methods have been used to estimate the hardness of butter and butterfat. The method most commonly employed has been to measure the depth of penetration of rods of known weight into the material to be tested. One of the best examples of the apparatus employed for this method is that of Perkins (1) who reviews the more important literature on the subject prior to 1914.

The values herein reported for the hardness of the butter and butterfat were determined by the use of an apparatus similar to that used by Templeton and Sommer (2) for measuring the body of cheese. It was found necessary to use cubes of a different size than those used by Templeton and Sommer, and a special technique in their preparation. The hardness of the butter or butterfat was measured by determining the force required to crush a three-fourths inch cube to two-thirds of its original thickness. The weight (in grams) of mercury required was used as a measure of the relative hardness of the sample. The actual force required to crush the cube was, however, five times that indicated by the grams of mercury since the pulley-arrangement gave a mechanical advantage of 5.

The cubes of butter or butterfat were prepared in brass molds of the proper size. The butter was carefully tamped into the molds immediately after working. The molds were placed in the refrigerator at – 18° C. for 24 hours, after which the cubes were removed from the molds, and tempered in a water bath maintained at 12° C. ($\pm$ 0.25) for 24 hours before being used for the hardness determination.

The cubes of butterfat were prepared using the same molds. The molds were placed on trays and set at –18° C. for a sufficient period of time to be

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thoroughly chilled. The melted butterfat at about 37° C. was poured into the molds and tempered in the same way as the butter cubes before being used for the hardness determination. Six cubes were prepared for each sample. The hardness values reported are an average of the determinations made on the six cubes.

Accuracy of the hardness determination: The force required to crush different cubes of the same sample of butter or butterfat varied appreciably due probably to mechanical defects in the cubes. Maximum deviation from the mean, however, rarely exceed 5 per cent for individual cubes. Satisfactory agreement was consistently secured on determinations made on separate churnings of the same cream. Representative values are shown in table 1.

TABLE 1

Comparative hardness of butter and butterfat from different churnings of the same lot of cream

CHURNING	HARDNESS OF BUTTER	HARDNESS OF FAT
number	*grams*	*grams*
1	574	1250
2	578	1303
3	549	1255
4	572	1223
5	573	1218
6	542	1203
7	579	1193
8	558	1246
Mean	566	1236
Standard deviation	13.1	32.7

ORIGIN OF BUTTER SAMPLES

The butter samples were churned from cream secured from cows in the University herd. The cream was separated from the milk of individual cows for 199 churnings and from the milk of groups of cows for 104 churnings. A standard[1] churning and working procedure was used for those samples on which values are reported for the hardness of butter in order

[1] The cream after separation was cooled, standardized with skimmilk to 30 per cent butterfat and held at 5° C. for 5 hours. A battery of two gallon glass churns of the "Dazey" type was used in an arrangement similar to that devised by Guthrie and Sharp (3). Six pounds of cream were weighed into the churns and the whole held in the water bath at 11° C. for one hour before churning. The churning temperature used was 11° C. The butter granules were washed once with a volume of water equal to the volume of buttermilk at 11° C. All free moisture was allowed to drain from the granules and the butter worked with a wooden butter ladle on a board arranged in such a fashion that the surplus water could readily drain away. The butter was worked until the moisture was judged to be thoroughly incorporated.

to eliminate in so far as possible the effect of variations in the churning and working conditions on the hardness of the butter.

RELATION BETWEEN HARDNESS OF BUTTER AND HARDNESS OF BUTTERFAT

The assumption is logical that the hardness of butter should be dependent to a large extent upon the hardness of the butterfat. No experimental evidence is available, however, in support of this assumption. Perkins (1) found no direct relation between the hardness of the butter and the hardness of the butterfat among 3 samples examined. Unquestionably, factors other than the hardness of the butterfat may influence the hardness of the butter. These may reasonably include the moisture content, the distribution of the moisture, and the air content of the butter, as well as variations in the churning and working conditions. For example, Perkins secured marked differences by varying the working conditions. Haglund, Wode, and Olsson (4) and Wode (5) were able to produce permanent variations by changes in the manufacturing methods.

Since the hardness of butter is affected by factors other than the character of the butterfat, it was considered desirable to relate variations in the composition of the butterfat to the hardness of the butterfat rather than to the hardness of the butter. The influence of variations in the composition of butterfat on the hardness of butter can then be interpreted from the relation between the hardness of the butter and the butterfat.

Hardness determinations were made on 85 samples of butter and on the butterfat rendered from the butter. The relationship between the two variables is shown in figure 1. It is evident from the chart that the hardness of these samples of butter, made under uniform conditions, is closely dependent upon the hardness of the butterfat. The correlation coefficient

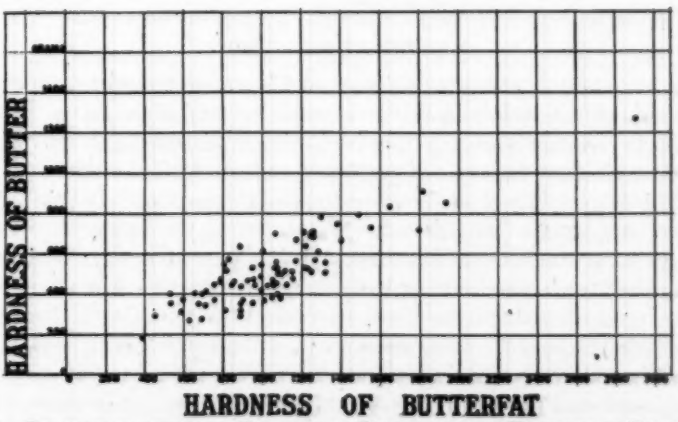

FIG. 1. RELATION BETWEEN THE HARDNESS OF BUTTER AND THE HARDNESS OF BUTTERFAT.

between the two sets of values is +0.87 with a P value (Fisher (6)) of less than 0.01. The correlation is thus highly significant. The hardness of the butter (x_1) may be estimated from the hardness of the butterfat (x_2) by the regression equation $x_1 = 0.42\ x_2 + 80.7$ with a standard error of estimate of 82 grams. The relationship between the two variables appears to be strictly linear.

RELATION BETWEEN THE HARDNESS OF BUTTER AND MOISTURE CONTENT OF BUTTER

Though the hardness of the butter is thus closely dependent upon the hardness of the butterfat, considerable variation in the hardness of the butter samples is unaccounted for. The moisture content of the butter samples ranged from 11.0 to 26.6 per cent. Variations of this magnitude should influence the hardness. The inclusion of the moisture content of the butter (x_3) as an independent variable influencing the hardness of the butter results in the regression equation, $x_1 = 0.382\ x_2 - 12.07\ x_3 + 285.6$. From this equation the hardness of the butter may be estimated with a standard error of estimate of 77 grams. The multiple correlation coefficient is 0.89.

Further proof that variations in the moisture content of the butter slightly, though significantly, influence its hardness is evidenced by the partial correlation coefficients. The partial correlation coefficient between the hardness of the butter and the moisture content of the butter with the hardness of the butterfat held constant is −0.34, with a P value of less than 0.01. The partial correlation coefficient between the hardness of the butter and the hardness of the butterfat with the moisture content of the butter held constant is +0.86.

RELATION BETWEEN IODINE NUMBER OF BUTTERFAT AND MOISTURE CONTENT OF THE BUTTER

In view of the standard churning and working procedure which was used, the marked variations in the moisture content of the butter must be related to variations in the character of the butterfat. Hunziker and associates (7) first pointed out that the unsaturated fatty acids in the butterfat have an influence on the moisture-retaining properties of the butter. Palmer (8) suggests that a probable explanation of this fact is found in the work of Langmuir, and of Harkins and associates, showing that it is the unsaturated fatty acids which increase the water-covering capacity of a fat. In the present data, there is a direct relationship between the iodine number of the butterfat and the moisture content of the butter. This is shown in figure 2 in which the moisture content of the butter samples is shown plotted as ordinates and the iodine number of the butterfat as abscissas. It is plainly evident that the moisture content of the butter increases with an

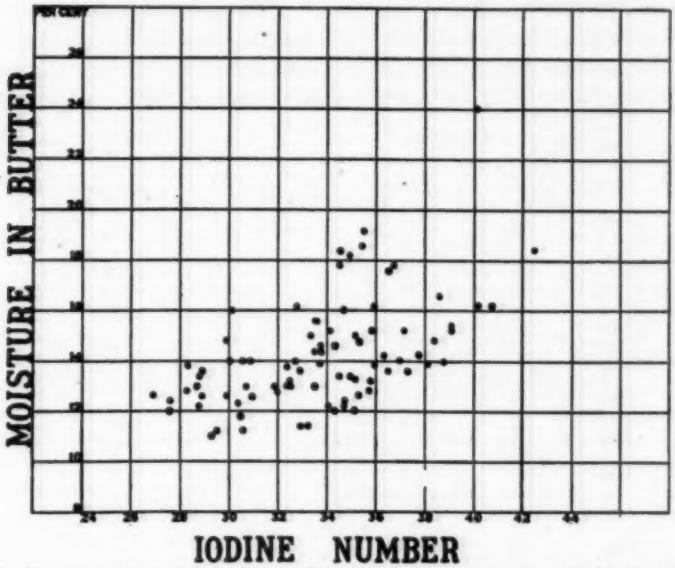

FIG. 2. RELATION BETWEEN THE IODINE NUMBER OF BUTTERFAT AND THE MOISTURE CONTENT OF THE BUTTER.

increase in the iodine number of the butterfat. The correlation coefficient between the two sets of values is + 0.55 with a P value of less than 0.01. One sample with a moisture content of 26.6 per cent has not been included in this comparison, since the sample was too small to permit working the butter by the standard procedure.

RELATION BETWEEN FAT CONSTANTS OF BUTTERFAT AND ITS HARDNESS

Several investigators, notably Haglund, Wode, and Olsson (4), have shown that the hardness of butter is inversely proportional to the iodine number of the butterfat. These workers used the Perkins method for determining the hardness of 413 samples of creamery butter. The iodine number of the butterfat and hardness were plotted and fitted to a third degree parabola. The equation found for the curve was $x = -2.04 - 0.572\,y + 0.0351\,y^2 - 0.000734\,y^3$. The correlation coefficient was 0.922 ± 0.007. These values indicate a close relation between iodine value and hardness of butter. Variations in the hardness of samples with the same iodine values were ascribed, by these workers, to differences in the manufacturing process.

Figure 3 shows the relationship between the hardness of butterfat and the iodine value for the 303 samples[2] on which data were secured in this

[2] Data for 59 samples from an experiment supervised by Dr. W. E. Petersen are included in this analysis.

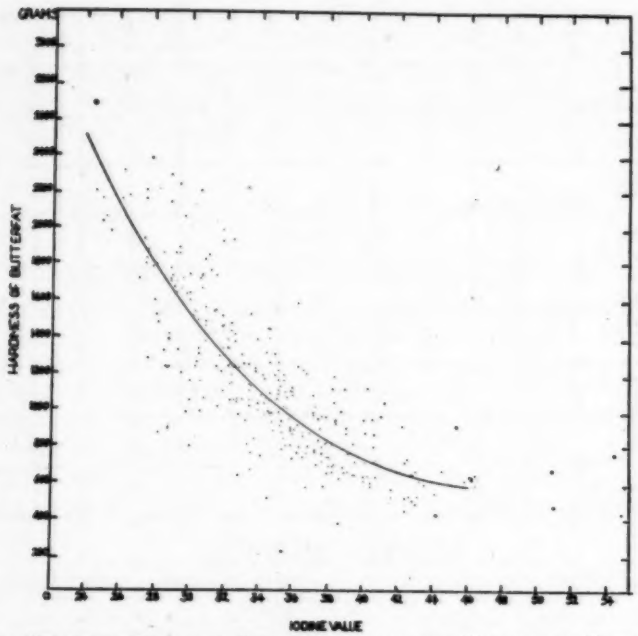

FIG. 3. RELATION BETWEEN THE IODINE NUMBER AND THE HARDNESS OF BUTTERFAT.

work. The hardness values are plotted as ordinates and the iodine numbers as abscissas. The relationship between the two variables, as seen from the chart, is definitely curvilinear. The method followed in working out the correlation index was that given by Ezekiel (9). The observations were grouped and averaged and a free-hand curve drawn through the mean values as smoothly as possible. This curve established the estimated value for the hardness of butterfat corresponding to a given iodine value. The correlation index determined in this way between the two sets of values is 0.85, which has a P value of less than 0.01. The standard error of estimate is 238.5 grams. This error of estimate represents 53 per cent of the standard deviation of the original values for hardness of butterfat.

Haglund, Wode, and Olsson (4) attribute deviations from the regression curve of hardness of butter as determined by iodine value to variations in the method of manufacture. This cannot be a factor when dealing with hardness of butterfat. The Reichert-Meissl number of the butterfat was determined as well as the iodine number. The inclusion of the Reichert-Meissl number in a multiple correlation indicated that considering the data as a whole, variations in the Reichert-Meissl number did not significantly influence the hardness of the butterfat. Extreme variations in the

Reichert-Meissl number may, however, be associated with considerable changes in the hardness of the butterfat. This can be shown from the data for individual cows in which there were extreme variations in the Reichert-Meissl number. This is shown in figure 4 in which the deviations from the

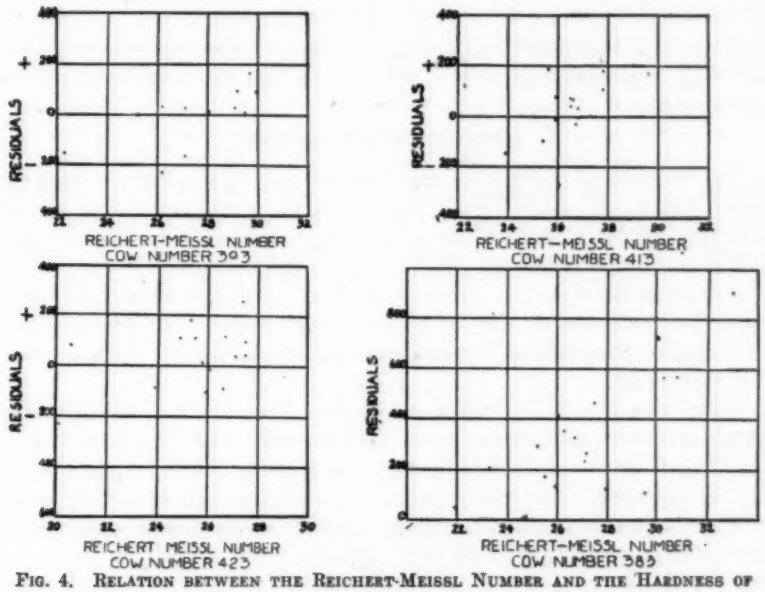

FIG. 4. RELATION BETWEEN THE REICHERT-MEISSL NUMBER AND THE HARDNESS OF BUTTERFAT.

regression curve are plotted as ordinates and the values for the Reichert-Meissl number as abscissas. The data for cows 383 and 423 show a definite decrease in the hardness of butterfat with an increase in the Reichert-Meissl number. On the other hand the data from cow 393 and especially from cow 413 do not show this relationship. This is probably due to the comparatively narrow range of the Reichert-Meissl values for the fat from these animals. It is evident from chart 4 that when the Reichert-Meissl values range from 25 to 28 the hardness of the butterfat may vary without regard to the Reichert-Meissl number. Variations in the Reichert-Meissl number beyond this range appear to be correlated with the hardness.

Factors such as variations in the fatty acid composition of the butterfat other than those revealed by the iodine number and the Reichert-Meissl number, or variations in the glyceride structure of the butterfat, must be responsible for most of the deviations from the regression curve of the data herein reported.

A noticeable difference was observed in the deviation from the regression curve of samples from the various breeds. The mean deviations were as follows:

Breed	*Number of Samples*	*Mean Deviation*
Ayrshire	19	+ 69
Holstein	129	+107
Channel Island	51	− 69

Thus it is apparent that the Channel Island breeds produce butterfat which for a given iodine value is firmer than that produced by Holsteins or Ayrshires.

SUMMARY AND CONCLUSIONS

The method of Templeton and Sommer for measuring the body of cheese was found adaptable for determining the hardness of butter or butterfat. When a standard churning and working procedure is used, the hardness of butter is directly proportional to the hardness of the butterfat. Variations in the moisture content of the butter slightly influence its hardness. The moisture content of butter, where a standard churning and working procedure is used, increases with an increase in the iodine number of the butterfat.

There is a highly significant correlation between the hardness of the butterfat and the iodine number of the butterfat. Extreme variations in the Reichert-Meissl number of the butterfat may be associated with variations in the hardness of the butterfat. Butterfat from cows of the Jersey or Guernsey breeds is somewhat firmer than butterfat with the same iodine value from cows of the Holstein or Ayrshire breeds.

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THE RELATION OF THE COMPOSITION OF BUTTERFAT TO THE CHURNABILITY OF CREAM*

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The Division of Dairy Husbandry of the University of Minnesota has been interested for several years in controlling the fat losses in buttermilk when churning sweet cream. At the Minnesota State Experimental creamery, which was operated under the supervision of the University, an effort was made to reduce such fat losses to a minimum. This work was started in 1926. After that date observations were made on 3800 churnings. The data, on which this report is based, have accumulated since 1927, when it was observed that the monthly average fat content of the buttermilk fluctuated widely and without exhibiting any definite trends. By systematic checking of the butterfat losses and by giving careful attention to churning

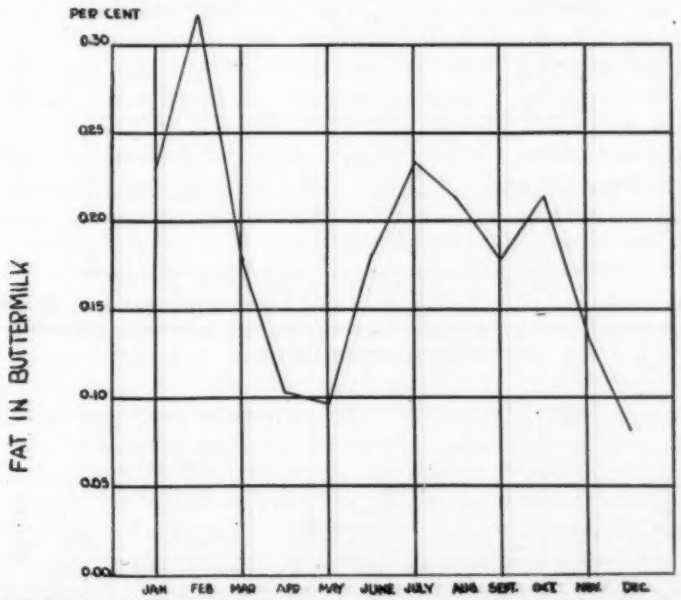

FIG. 1. MONTHLY AVERAGE FAT PERCENTAGES OF BUTTERMILK AT MINNESOTA STATE EXPERIMENTAL CREAMERY. 1927.

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* The data in this paper are taken in part from the thesis presented by S. T. Coulter in partial fulfillment of the requirements for the degree of Ph.D., University of Minnesota, 1933. Paper 1260, Journal Series, Minnesota Agricultural Experiment Station.

conditions, the fat content of the buttermilk was markedly reduced in the years that followed. This is shown by comparison of the data for 1927 (Fig. 1) with those for the years 1930 and 1931 (Figs. 2 and 3). The plotted values are the monthly average fat percentages of the buttermilk according to the Standard Babcock test. It is believed that the fat percentages during the years 1930 and 1931 represent, approximately, the minimum which it is possible to secure under commercial conditions when churning sweet cream untreated except for pasteurization.

There was a strikingly uniform seasonal change in the fat content of the buttermilk during the years from 1929 to 1932. The values for 1929 and 1932 are not shown on the charts but are similar to those from 1930 and 1931. The increase in the fat percentage during the months of May, June,

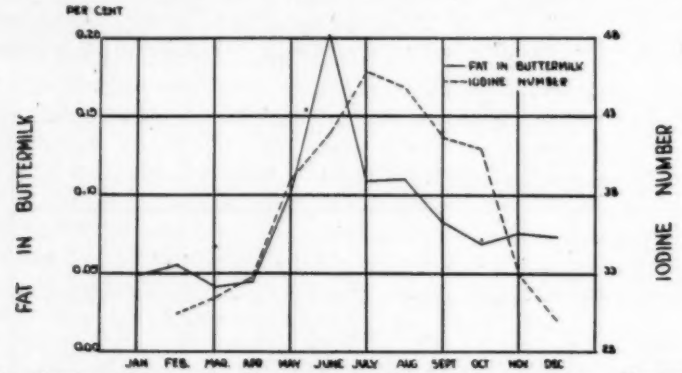
PER CENT
FAT IN BUTTERMILK
IODINE NUMBER
FAT IN BUTTERMILK
IODINE NUMBER
JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC

FIG. 2. MONTHLY AVERAGE FAT PERCENTAGES OF BUTTERMILK, AND IODINE NUMBERS OF THE BUTTERFAT FROM MONTHLY COMPOSITE SAMPLES OF BUTTER. MINNESOTA STATE EXPERIMENTAL CREAMERY. 1930.

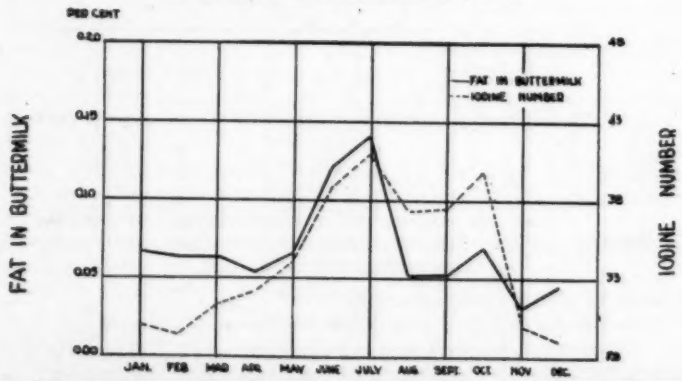
PER CENT
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FIG. 3. MONTHLY AVERAGE FAT PERCENTAGES OF BUTTERMILK, AND IODINE NUMBERS OF THE BUTTERFAT FROM MONTHLY COMPOSITE SAMPLES OF BUTTER. MINNESOTA STATE EXPERIMENTAL CREAMERY. 1931.

and July persisted despite the use of extremely low churning temperatures with consequent prolonged churning periods. Buttermakers commonly use lower churning temperatures during this season because of the softness of the butterfat. The data indicate, however, that there is a seasonal variation in the maximum recoverability of butterfat from cream on churning. This variation appears to be associated with the seasonal changes in the composition of the butterfat. Monthly composite samples of the butter were secured during 1930 and 1931. The fat from the butter was rendered and the iodine number determined. The peak values for butterfat losses and iodine numbers were in June and July at which time the cows are fed almost exclusively on pasture. The rise in both values in October, 1931, is interesting. Heavy rains in this section during early October of that year, following a dry summer, revived the pastures. The resulting change in the character of the pasture grass or in the amount of grass consumed by the animals is reflected in the change in the composition of the butterfat.

These observations aroused interest in the relation between the composition of the butterfat and the churnability of the cream. Further studies were therefore made with the cream from the milk of individual cows.

Equipment, similar to that described by Guthrie and Sharp (1), was used for these studies on churnability. This consisted of a battery of four 2-gallon glass churns with contained agitators which were driven through gears from the same line shaft. The electric motor used to propel the line shaft was sufficiently powerful to permit the removal of one or more of the churns without changing the speed appreciably. The glass portion of the churns was almost entirely immersed in a water bath maintained at 11° C.

The combined milk produced by the individual cows during periods of two consecutive days was separated, standardized with skimmilk to 30 per cent butterfat, and held in the refrigerator at 5° C. for five hours. Six pounds of cream were weighed into the churns and held in the water bath at 11° C. for one hour before churning. The churning time was recorded and the percentage of fat in the buttermilk was determined by using the Minnesota reagent in the Babcock test. In order to avoid incorporating in the buttermilk any unchurned portions of the cream that may adhere to the top of the churn during the churning process, it was necessary to pipette or siphon sufficient buttermilk for analysis from the bottom of the churn.

Guthrie and Sharp (1) noted a difference in the time required to churn with different churns. This situation was not observed in the equipment used for this work. Excellent agreement, both as to churning time and the percentage of fat in the buttermilk, was consistently secured when churning different lots of the same cream.

Determinations of the iodine and the Reichert-Meissl numbers were made on the rendered, filtered butterfat. In addition, the hardness of the butterfat was determined with the equipment described by Coulter and Hill (2).

Several investigators, including Coulter and Hill (2), have shown that the hardness of butter or butterfat is closely correlated with the iodine number of the butterfat. The hardness of butterfat increases with decrease in iodine number.

Two series of experiments were conducted, in the first of which, the hardness determinations were made at 11° C., and in the second at 12° C. In the first series, data were secured on 9 churnings from the cream of each of three cows, two Holstein and one Brown Swiss. In the second series, data were obtained on 42 churnings with cream from 5 Holstein, and from 2 Guernsey cows.

RELATION BETWEEN THE CHURNABILITY OF CREAM AND THE HARDNESS OF BUTTERFAT

The data secured in this work indicate that the time required to churn different lots of cream from the same cows is directly proportional to the hardness of the butterfat. This relationship is shown in figures 4 and 5 in which the churning times have been plotted as ordinates and the hardness of the butterfat samples as abscissas. The data in figure 4 are for series 1, and in figure 5 for series 2.

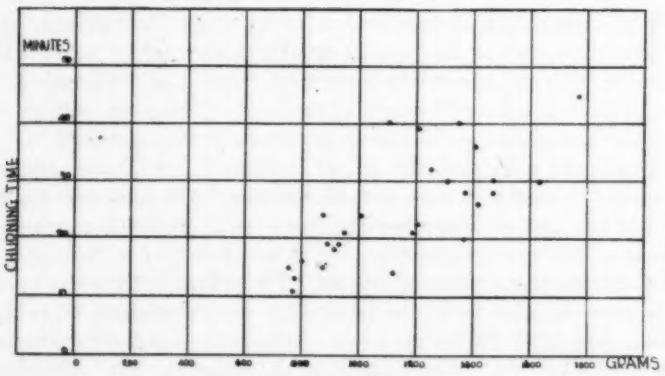

FIG. 4. RELATION BETWEEN THE CHURNING TIME OF CREAM AND THE HARDNESS OF BUTTERFAT. SERIES 1.

It is manifest from these data that the churning time of different lots of cream from the same cows increases with an increase in the hardness of the butterfat. The correlation coefficient, between the churning time and the hardness of the butterfat for the data in the first series is 0.74; for the Holstein cows in the second series, 0.81; and for the Guernsey cows in the second series, 0.85.

It was observed that the Guernsey cream, in series 2, churned in a shorter period of time than the Holstein cream containing butterfat of the same hardness. This is clearly indicated by the plotted data in figure 5. This result would seem logical since the fat in the milk of Guernsey cows

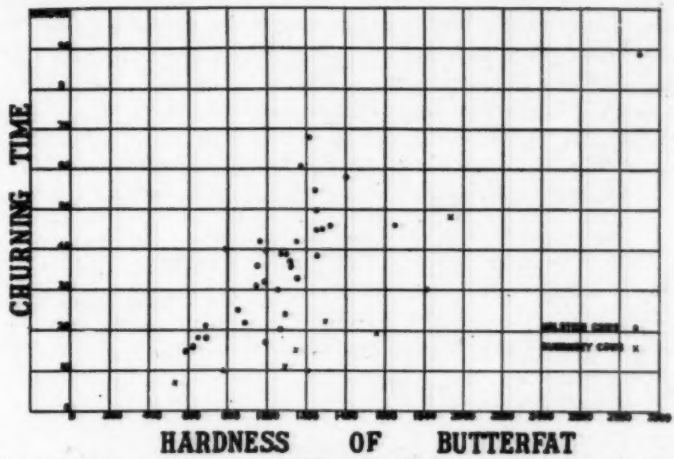

FIG. 5. RELATION BETWEEN THE CHURNING TIME OF CREAM AND THE HARDNESS OF BUTTERFAT. SERIES 2.

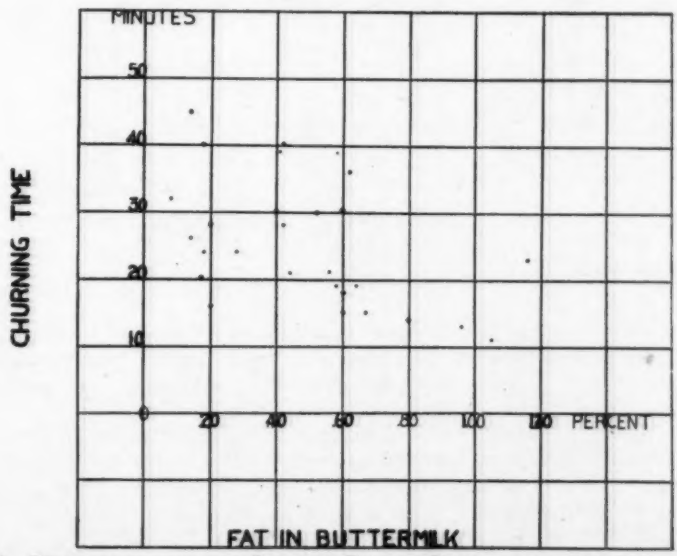

FIG. 6. RELATION BETWEEN THE CHURNING TIME OF CREAM AND THE FAT CONTENT OF THE BUTTERMILK. SERIES 1.

commonly occurs as larger globules than that from Holstein cows. Large fat globules churn more readily than small ones.

The relationship between the hardness of the butterfat and the churning time appears to be essentially linear except with the softer butterfats and the shorter churning time. Since cream containing butterfat with a hypothetical hardness of zero would not churn spontaneously but would require an interval of time for agitation, a regression line of churning time as determined by hardness of butterfat would start at some point greater than zero on the time axis. This is indicated by the plotted data.

The fat content of the buttermilk was the lowest in the samples requiring the longest time to churn. These samples contained the hardest butterfat. The data for series 1 are shown in figure 6, and for series 2, in figure 7.

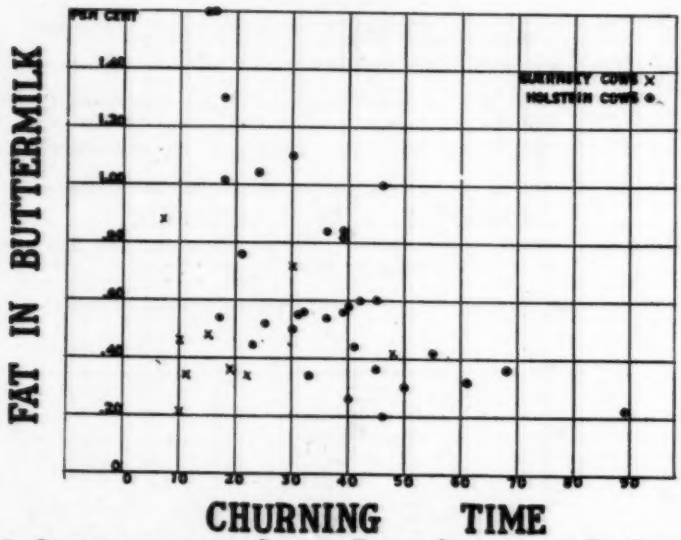

FIG. 7. RELATION BETWEEN THE CHURNING TIME OF CREAM AND THE FAT CONTENT OF THE BUTTERMILK. SERIES 2.

The fat percentages of the buttermilk samples are plotted as ordinates, and the churning times in minutes as abscissas. Although the results are quite variable, there is a definite tendency for the fat content of the buttermilk to increase with a decrease in churning time.

DISCUSSION

The data clearly show that the churnability of the cream is influenced by the hardness of the butterfat. Although hardness determinations were not made on butterfat from the monthly composite samples of butter

received from the State Experimental Creamery, the hardness of the butterfat may be expected to have followed closely the changes in the iodine number. Since the relation between the churning time of cream and the hardness of butterfat is essentially linear, alteration of the churning temperature may be expected to equalize the churning time with creams containing hard and soft butterfat. This is illustrated by the work at the State Experimental Creamery, where the churning temperature has been adjusted with the changing seasons to secure an almost constant churning time. In fact, during the years from 1929 to 1932 the churning time during the summer months has usually been longer than the churning time during the winter months. This is due to the very low churning temperatures used during the summer months. Although the churning time of cream containing hard and that containing soft butterfat may thus be equalized by alteration of the churning temperature, such adjustment to equalize the churning time does not appear to reduce the fat content of the buttermilk, when churning cream containing soft butterfat, to a point comparable with that for cream containing hard butterfat.

SUMMARY AND CONCLUSIONS

Data which indicate a seasonal variation in the fat content of buttermilk are presented. This variation appears to be associated with the seasonal fluctuations in the iodine number and thus with the changes in the hardness of the butterfat. It has been shown, experimentally, that the churning time of cream from the same cows is prolonged when there is an increase in the hardness of the butterfat, and also that the fat content of the buttermilk decreases with an increase in the time required for churning.

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THE OCCURRENCE OF POLYTHELIA IN DAIRY CATTLE*

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At the present period in the evolutionary development of dairy cattle, the females normally have four milk secreting glands, or mammae. Associated with each of these mammae is the papilla mamma, commonly called a teat or nipple, which serves as an exit for the secretion produced in the mammary gland. It is not uncommon, however, to observe individuals that have in addition to the four "normal" teats a variable number of additional teats, some of which are the orifices of small glands, others may be without glands and yet others may open into one of the normal glands. This condition of polythelia is usually referred to as supernumeraries, after teats, abortive teats, or extra teats.

There is a tendency for the majority of dairy cattle breeders in the United States to look upon polythelia with disfavor since the appearance of extra teats detracts from the beauty of the cow and also because the glands associated with the extra teats frequently produce small amounts of milk, thereby causing irregularities and difficulties in the milking process. A few breeders, however, believe that supernumeraries are associated with abundant milk and butterfat production.

Therefore, a genetic analysis of the inheritance of the supernumerary teats would be most valuable to dairy cattle breeders as an aid in the selection of their breeding animals so that they could decrease the frequency of the polythelial condition if it should be desirable. Before such a study is to be initiated, however, it would seem desirable to secure definite information as to the frequency of occurrence and the normal locations, which we may designate as pattern, of the supernumeraries as they now occur in our various breeds of dairy cattle.

Therefore, it was the plan of this investigation to collect data on large numbers of individuals in the various breeds of dairy cattle in order to secure the supernumerary teat patterns and the frequency of their occurrence. No attempt will be made in this paper to determine the genetic behavior of the factors causing the somatic appearance of these extra teats.

REVIEW OF LITERATURE

Without doubt supernumerary teats were observed by breeders at an early period in the development of dairy cattle, but a discussion of their

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occurrence, in the literature, seems to be limited to the recent three quarters century.

The first description that has been found by the author was given in 1862 by May (11). He mentioned the fact that there may appear one or two small pseudo teats on the rear glands that were considered favorable signs. Sutton (12) also described the polythelial conditions in the cow and other animals.

In a book on variation, Bateson (1) states that, "Normally the cow has four teats of about equal size. Not infrequently there are six teats of which four are large and may be said in the usual parlance to be the "normal" ones, and two are small and placed posteriorly to the others. . . . Their size and position vary greatly; sometimes they are placed near the other teats . . . but I have seen them very high up, almost in the fold between the udder and the thighs. Very frequently, however, there is only one extra teat, making five in all, such an extra teat being so far as I know, always on one side of the udder."

Burchard (2) compared the number of supernumeraries that occur in growing cattle with those found on the mammary gland of embryos. Approximately 38 per cent of all the individuals examined showed abortive teats, as he classified them.

Henneberg (6) made a very extensive study of the frequency of occurrence of supernumerary teats in various breeds of European cattle. He examined 2373 females and found that approximately 39 per cent of these animals possessed supernumeraries.

Mackenzie and Marshall (10) examined 276 dairy cows and heifers at the Cambridge University Farm and at seven other dairy farms for the occurrence of accessory or supernumerary teats. They found that the supernumeraries occurred in more than 50 per cent of the animals observed. The numbers varied from one to three.

Juler (8) reported 1472 observations on the breeds of dairy cattle in Germany and found that about 23 per cent showed the so-called "after teats."

Emmerson (3) examined the udders of 370 beef and dairy cattle and found that 44 per cent of the individuals exhibited supernumerary teats.

Ivanova (7) studied about 4000 cattle in U. S. S. R. for the occurrence and gave the various locations and patterns of supernumerary teat placements on 800 individuals, but did not indicate the percentage of animals that showed the characteristic.

Leroy (9) observed that among a group of 90 experimental cows representing the different breeds in France, there were only 28 cows that did not possess the supernumerary teats. In other words, approximately 69 per cent of the animals in this group exhibited the polythelial condition.

Turner (13 and 14) reported a study of 40 female and 46 male bovine

fetuses. Fifty per cent of the females had the supernumerary teats, while only 17 per cent of the males had more than the four rudimentaries.

A summary of the percentage of supernumerary teats of all kinds in relation to the normal number as reported by these various investigators is given in Table 1.

TABLE 1

Summary of the data on the occurrence of supernumerary teats in cattle

BREED	TOTAL NUMBER OF ANIMALS INCLUDED	TOTAL NUMBER OF ANIMALS WITH SUPERNUMERARIES	PERCENTAGE OF ANIMALS WITH SUPERNUMERARIES	AUTHORITY
Unclassified cattle			37.62	Burchard (1897)
Embryos—male			39.58	" "
" —female			35.13	" "
Holländer	122	34	27.87	Henneberg (1904)
Ostfriesen	339	94	27.73	" "
Krenzung aus Holländer und Ostfriesen	40	18	45.00	" "
Oldenburger	114	51	44.74	" "
Shorthorn	40	16	40.00	" "
Rotbunte Schleswig-Holsteiner	132	57	43.18	" "
Rote Schleswiger	243	73	30.04	" "
Braunveih	215	84	39.07	" "
Gelbe einfarbige Tallandrinder	110	36	32.73	" "
Einfarbig Rotes u. Rotbr. veih	476	185	38.86	" "
Braun- und Rotblassige Rinder	18	4	22.22	" "
Rückenscheecken	43	17	39.53	" "
Grosse Hohenfleckveih	481	257	53.43	" "
Dairy Shorthorns	175	105	60.00	Mackenzie & Marshall (1925)
Devon	81	40	49.38	" "
Jersey	8	5	62.50	" "
Beef & Dairy Cattle	370	163	44.05	Emmerson (1928)
Various breeds in Germany	1472	338	22.96	Juler (1927)
Various breeds in France	90	62	68.88	LeRoy (1928)
Embryos—female	40	20	50.00	Turner (1930, 1931)
" —male	46	8	17.39	" " "
Various dairy breeds in Missouri—				
females	4831	1249	25.85	(This paper)
males	135	19	14.07	" "

SOURCE OF DATA

This investigation was started by examining the number and distribution of the teats on all animals in the dairy herd at the Missouri Agricultural Experiment Station in 1926. These observations have been continued since that date at regular intervals. It was later found possible to obtain similar observations from more than 230 herds of dairy cattle in various sections of Missouri, through the cooperation of a carefully selected group of Advanced Registry supervisors and dairy herd improvement association

testers.[1] These men were given thorough instructions and were furnished with forms for facilitating the accuracy and ease of securing reports.

POSITION AND PATTERN OF SUPERNUMERARY TEATS

In general, there are three types of supernumerary teats that have been observed—caudal, or those found at the rear of the normal; intercalary or those found between the normal teats; and ramal, or the supernumeraries that are ramifications and branches of the normal teats. Supernumeraries anterior to the normal have not been observed.

In general, each of these three types have a rather definite maximum number of possible locations on the udder for supernumerary attachments. The caudal type may have four supernumeraries, one pair just posterior to the normal teats, and a second pair posterior to the first pair of supernumeraries and placed well up on the rear quarters of the udder, but may be near the median line. The intercalary supernumeraries are attached to the floor of the udder and may occur at various points between the normal teats on each half of the udder. They are usually in line with the two normal teats on each half of the udder. The ramal type appears at the base of the normal teat or on the side of the teat and may be attached on the inner or outer position, or caudal or craniad to the normal teat.

Figure 1 illustrates the three types of supernumeraries commonly ob-

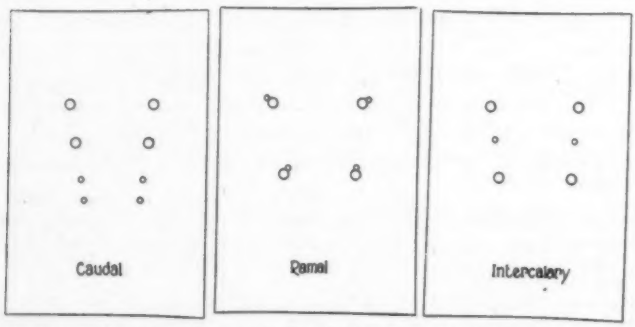

FIG. 1. DIAGRAMS ILLUSTRATING THE THREE TYPES OF SUPERNUMERARIES COMMONLY OBSERVED ON THE UDDERS OF DAIRY COWS

served and shows the most probable locations while figure 2 shows photograph of observations of each of these types.

One or more of the supernumeraries in each of the three types may occur on a single udder. Therefore, in order to facilitate the grouping and classi-

[1] This second procedure was initiated by Dr. Chas. W. Turner, Dairy Department, University of Missouri, and the writer is greatly indebted to him for about one-third of the observations obtained for this study and for other valuable suggestions.

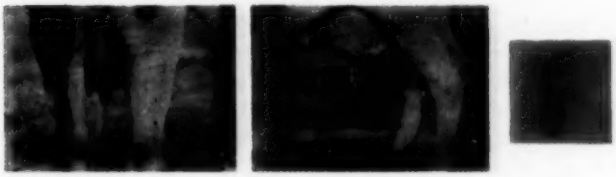

FIG. 2. PHOTOGRAPHS SHOWING THE VARIOUS TYPES OF SUPERNUMERARY TEATS
1. Two caudal supernumeraries
2. An intercalary supernumerary
3. An amputated teat showing ramal supernumerary.

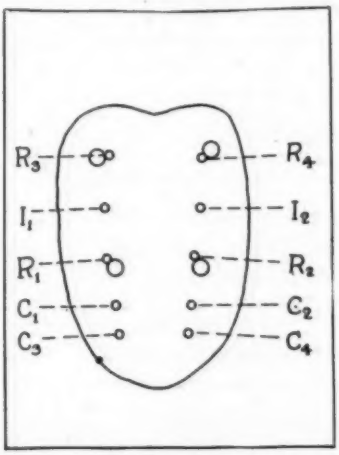

FIG. 3. DIAGRAM ILLUSTRATING THE HYPOTHETICAL POSSIBLE LOCATIONS OF SUPERNUMERARY TEATS ON A SINGLE UDDER WITH IDENTIFICATION NUMBERS

fication of supernumerary patterns on the various udders studied, figure 3 is presented giving the hypothetical possible locations on a single udder with identification numbers. It will be noted that those appearing on the left half of the udder are designated by odd numbers while those on the right are marked by even numbers.

The frequency of appearance of supernumerary teats in the caudal, intercalary, and ramal positions, as well as the various combinations of the three types that have been reported by various investigators, are summarized in table 2.

In the present investigation, 4831 female individuals have been observed. This number includes cows and heifers of the Holstein-Friesian, Jersey and Guernsey breeds and a number of animals of mixed or unknown breeding. A summary of the observations shows that 1249 of these animals

TABLE 2

Summary of the teat patterns reported for various breeds of dairy cattle

BREED	0	CAUDAL 1	2	3	4	INTERCALARY 1	2	INTERCALARY AND CAUDAL 1	2	RAMAL	AUTHORITY
Holländer	88	16	16	1	0	0	2	0	0	....	Henneberg (1904)
Ostfriesen	245	41	45	4	1	2	1	2	0	....	" "
Krenzung aus Holländer und Ostfreisen	22	8	8	1	0	1	0	4	0	....	" "
Oldenburger	63	23	23	1	1	3	0	2	0	....	" "
Shorthorn	24	10	6	0	0	0	0	0	0	....	" "
Rotbunte Schleswig-Holsteiner	75	34	20	1	0	2	0	3	0	....	" "
Rote Schleswiger	171	40	31	1	0	0	0	1	0	....	" "
Braunveih	132	54	29	0	0	0	0	0	1	....	" "
Gelbe einfarbige Talland Rinder	74	22	14	0	0	0	0	0	0	....	" "
Einfarbig Rotes u. Rotbr. Veih.	291	107	77	0	0	1	0	1	0	....	" "
Braun-und Rotblassige Rinder	14	3	1	0	0	0	0	0	0	....	" "
Ruckenschecken	28	7	8	0	0	0	0	2	0	....	" "
Grosses Hohenfleckveih	224	116	131	3	0	6	1	8	0	....	" "
Dairy Shorthorn	70	52	48	5	...	.....	...	...	...	....	Mackenzie & Marshall (1925)
Devon	41	15	23	2	...	.....	...	...	...	....	" " "
Jersey	3	2	1	2	...	.....	...	...	...	....	" " "
Beef & Dairy Cattle	207	83	71	9	0	8	0	...	...	....	Emmerson (1928)
Various breeds in U.S.S. Russia		371	377	22	0	3	0	0	0	27	Ivanova (1928)
Various breeds—embryos											
female	20	10	10	0	0	0	0	0	0	0	Turner (1930–31)
male	39	6	1	0	0	1	0	0	0	0	
Dairy breeds in Mo.											
female	3582	737	431	15	3	49	8	...	...	33	(This paper)
male	116	9	10	.....	...	.....	...	...	...	....	" "

had one or more supernumeraries. These were grouped according to the pattern combinations illustrated in fig. 3. For example, if there were a caudal supernumerary on the left half of the udder and an intercalary on the right half, the pattern was designated as C – 1 + I – 2.

The frequency distributions and the location of supernumeraries observed as indicated by the pattern are given in table 3. All three types, caudal, intercalary, and ramal supernumeraries, were observed. In all, 36 different patterns were found and no doubt further observations will reveal that other combinations and patterns appear.

The caudal teats were far more numerous than the intercalary or ramal types. Of the 1249 cows exhibiting supernumerary teats, 1186 or 94.96 per cent possessed one or more caudal teats. This was 24.55 per cent of all cows observed. There were 737 or 15.25 per cent of the cows with only one caudal, 431 or 8.92 per cent with two caudal, 15 or 0.31 per cent with three and only 3 or 0.06 per cent with four caudal supernumeraries.

The intercalary teats only appeared on 56 or 1.16 per cent of the cows. Of these, 49 cows had only one while the remaining 7 had two. The ramal type was found to be most rare. Only 33 cows or 0.68 per cent were observed with this type of abnormal teats. Furthermore 24 of these cows had only one while 8 had two and only 1 possessed three.

With the above distributions of types of supernumeraries, it is quite natural that patterns C–1, C–2 and C–1 + C–2 should be most frequent. It will be noted from the distribution table that 1084 of the cows were actually classified in these three patterns.

In the other 33 patterns, the numbers are small. In no case were there more than 0.4 per cent of the total animals observed in any of these individual patterns. In fact there are eleven of these patterns with only one animal represented.

One unusual pattern, C–1 + C–2 + C–3 + C–1', was observed where a caudal supernumerary was attached to the rear quarter to the left of the normal location of caudal supernumeraries.

Another cow was observed that had only three normal teats. The teat on the left half of the udder served as an exit for the milk secreted in the entire half of the mammary gland. Emmerson (3) reported similar observations and Heizer (5) reports a number of such individuals that have appeared in a Guernsey family.

Emmerson (3) also reports the more unusual type of udder. Only two teats were present to drain the four glands.

Erizan (4) reports three observations where cows had only two teats. The first one described had two normally developed teats and the arrangement indicated that they formed the anterior pair. Both teats functioned normally and there was no indication of rear or supernumerary teats located on the posterior portion of the udder. This udder is shown in

TABLE 3

The occurrence and patterns of supernumeraries observed in dairy cows

TEAT PATTERN	PUREBRED JERSEY	GRADE JERSEY	PUREBRED HOLSTEIN-FRIESIAN	GRADE HOLSTEIN FRIESIAN	PUREBRED GUERNSEYS	MIXED BREEDS AND MISCELLANEOUS	TOTAL
Normal (4 only)	541	1290	321	1153	52	225	3582
C–1	21	95	34	198	9	29	386
C–2	21	93	30	114	11	48	317
C–1 + C–2	33	96	63	135	7	47	381
C–3	2	1	1	9	0	0	13
C–4	3	2	1	2	0	1	9
C–3 + C–4	2	5	1	7	0	3	18
C–1 + C–3	1	0	1	2	0	0	4
C–2 + C–4	0	1	0	0	0	0	1
C–1 + C–3 + C–2	0	3	2	1	0	0	6
C–2 + C–4 + C–1	0	3	1	1	0	1	6
C–3 + C–2 + C–4	0	0	0	0	0	1	1
C–1 + C–3 + C–4	0	0	0	2	0	0	2
C–1 + C–3 + C–2 + C–4	0	0	0	0	0	2	2
C–3 + C–2	0	2	1	4	0	1	8
C–1 + C–4	1	0	1	2	0	0	4
I–1 + I–2	0	0	0	0	0	1	1
I–1	1	0	6	9	0	1	17
I–2	1	2	1	9	0	1	14
I–1 + C–1	0	0	0	2	1	0	3
I–2 + C–2	0	0	0	0	0	1	1
I–1 + I–2 + C–1 + C–2	0	2	0	0	0	0	2
I–1 + I–2 + C–3 + C–2	0	0	1	0	0	0	1
I–1 + C–2	0	2	0	0	1	0	3
I–1 + C–1 + C–2	0	0	0	0	0	3	3
I–2 + C–1	0	2	0	0	0	0	2
I–2 + C–1 + C–2	0	3	2	4	0	0	9
R–2	1	2	2	3	1	1	10
R–1 + R–2	1	3	0	0	1	3	8
R–1	1	4	0	2	0	0	7
R–3	0	0	0	2	0	0	2
R–4	1	0	1	0	0	0	2
R–1 + R–2 + R–3	0	1	0	0	0	0	1
R–3 + C–1	0	1	0	0	0	0	1
R–1 + C–3	0	0	0	1	0	0	1
R–2 + C–1	1	0	0	0	0	0	1
C–1 + C–2 + C–3 + C–1[1]	0	0	0	0	1	0	1
3 normal	0	1	0	0	0	0	1

figure 4. In the case of the second and third observations, the two teats occupied a central position on the udder and represented an incomplete blending of the rear and front teats into one system similar to the observation made by Emmerson.

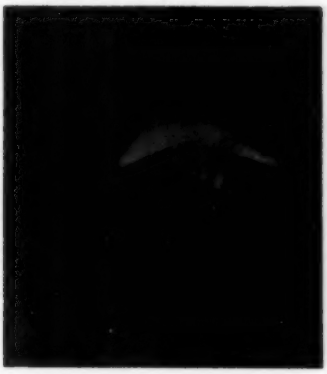

FIG. 4. PHOTOGRAPH OF A TWO-TEATED COW (FROM ERIZIAN)

THE OCCURRENCE OF POLYTHELIA IN BULLS

The supernumerary teats can also be observed on a number of dairy sires. The patterns in relation to the normal rudimentary teats are similar to those of the female patterns except these extra teats are usually located on the scrotum.

The small number of available bulls did not permit an extensive study of the supernumerary teat patterns of dairy sires. However, 135 bulls were examined. Of this number, 19 individuals or 14.07 per cent possessed

TABLE 4

Teat patterns observed in dairy bulls

TEAT PATTERN	PUREBRED JERSEYS	PUREBRED HOLSTEIN-FRIESIAN	PUREBRED GUERNSEY	MIXED BREEDS AND MISCELLANEOUS	TOTAL
Normal (4 only)	60	40	2	13	115
C–1	1	2	0	1	4
C–2	4	1	0	0	5
C–1–C–2	3	4	2	1	10
3 Rudimentaries (only)	0	1	0	0	1

one or more supernumeraries. The various patterns observed, when classified according to the patterns illustrated in figure 3, are given in table 4.

Only three patterns were observed and these were of the caudal type. One young Holstein-Friesian bull was observed that had only three normal rudimentaries. A similar observation was made by Turner (14) as he reports a male fetus from a Hereford dam that had only three rudimentaries.

SUMMARY

The frequency of occurrence and pattern distribution of supernumerary teat observed on 4831 female and 135 male dairy cattle have been compiled and reported. For the females, 25.8 per cent exhibited the polythelial condition. The caudal, intercalary and ramal supernumeraries were observed and were classified in 36 different patterns. The caudal type was by far the most common type observed since approximately 95 per cent of all females possessing the extra teats were of this type. Only 14.07 per cent of the males had one or more supernumeraries and these were classified in three patterns. One individual was observed with only three rudimentaries.

Data of similar investigations made by European workers and others have been compiled. On the average the frequency of occurrence of the polythelial condition found in the American breeds studied were less than that reported for the European breeds.

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THE BUTTERFAT RECORDS OF COWS POSSESSING SUPERNUMERARIES COMPARED WITH COWS HAVING THE NORMAL NUMBER OF TEATS*

WARREN GIFFORD

Missouri Agricultural Experiment Station, Columbia, Missouri

It is not an uncommon occurrence to have dairy cattle breeders question whether or not cows with supernumerary teats are superior in producing capacity to those that do not show the polythelial condition. As was described in an earlier paper, Gifford (2) these "extra teats" or supernumeraries are found quite commonly in dairy cattle and are usually of three types. They have been described as caudal, or those found in the rear of the normal teats, intercalary or those found between the normal, and ramal or those that are ramifications or branches of the normal.

In Russia and some other European countries, it has been reported that there is a prevailing belief among dairy cattle breeders that the presence of supernumeraries is evidence of abundant milk supply. In other words, the observations of these breeders have led them to believe that there is closely linked with the genes for the character capacity for large amounts of milk, the genes responsible for the development of the polythelial condition. Furthermore, their conclusion might indicate that the genes responsible for the development of these two characters are so closely linked that they appear together in a majority of instances. In fact, Ivanova (3) found that the cows possessing supernumerary teats had produced 388 kilograms or about 15 per cent more milk than those with the normal number of teats when she compared the records of 251 cows that exhibited this polythelial condition with 444 cows with the normal number. These cows were observed in 25 dairy herds on farms and at breeding stations in U. S. S. Russia.

On the other hand, Juler (4) working independently of Ivanova made a similar investigation on the records of the Angler cattle in Germany and the results were quite contradictory. Juler failed to find a significant difference between the annual production of milk and butterfat of the two groups. Leroy (5) substantiated Juler's findings when he examined 90 cows for the presence or absence of supernumerary teats and then compared the milk production of the two groups, taking as a basis for his comparison, the average mature or mature equivalent records for three successive lactations. The group of cows with the normal number of teats actually produced considerably more milk on the average than the other groups. The author

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suggests, however, that there is not a significant difference between the two groups.

During the compilation of the data used to determine the frequency of the occurrence of the polythelial condition in breeds of dairy cattle represented in Missouri, it was possible to secure the annual butterfat records for seven groups of dairy cows. Each group represented a breed or a subdivision of a breed upon which record had been kept in a definite organized manner. The total number observed with such records was 1081 cows.

The records of these cows were corrected to a common age basis by means of the conversion factors published in the Missouri Agricultural Experiment Station Bulletin No. 274. Then for each of the groups, the records were divided into two subgroups, those that were made by cows with one or more supernumerary teats and those made by cows with the normal number of teats. The mean of the records in each of these subgroups and the standard deviations were determined. These data are presented in

TABLE 1

A Comparison between the annual fat production of dairy cows with only four teats and those with supernumeraries

GROUP OF COWS	BREED	FOUR NORMAL TEATS SUPERNUMERARIES ABSENT			FOUR NORMAL TEATS ONE OR MORE SUPERNUMERARIES			DIFFERENCE IN POUNDS
		Number	Mean fat production	Standard deviation	Number	Mean fat production	Standard deviation	
1	Grade Jerseys	237	304.72	92.76	70	297.97	91.12	−6.75
2	Purebred Jerseys	36	258.25	85.48	6	251.81	40.97	−6.44
3	Grade Holsteins	264	299.31	85.07	129	296.59	71.01	−2.72
4	Purebred Holsteins	48	320.18	103.59	25	305.15	83.28	−15.03
5	Miscellaneous	45	258.53	78.82	35	265.97	76.77	7.44
6	R. of M. Jerseys	67	538.08	104.82	8	657.59	92.63	119.51
7	A.R.S.O. Holsteins	84	613.83	131.74	27	630.35	124.33	16.52

table 1. The average difference in pounds of fat between the two subgroups of records being compared are also shown in this table.

It will be noted from this table that in groups 1, 2, 3, and 4, respectively, the cows with the normal number of teats have a slightly superior yearly production on the average than do the cows with supernumeraries. In groups 5, 6, and 7, the situation is reversed and the cows with the supernumeraries have the highest average production. In order to determine whether these differences were significant or whether they may have arisen from mere fluctuations in sampling, t values were calculated and the significance determined by Fisher's tables (1). That is the $\sigma MD = \sqrt{\frac{\sigma^2_1}{N} + \frac{\sigma^2_2}{N}}$ when σ_1 and σ_2 represents the standard deviation of subgroups 1 and 2 respectively and N_1 and N_2 represent the number of records in each of the

two subgroups. Then $t = \frac{\text{Difference}}{\sigma \text{M.D.}}$. These constants are given in table 2. It will be noted from the t values that the differences observed between

TABLE 2

Constants showing the significance of differences found between the two groups of records

GROUP	DIFFERENCE IN POUNDS BETWEEN THE FAT PRODUCTION OF THE TWO GROUPS	DEGREES OF FREEDOM	VALUE OF T	SIGNIFICANT
1	6.75	305	.5423	No
2	6.40	44	.2931	No
3	2.72	391	.3335	No
4	15.03	71	.6715	No
5	7.44	78	.4250	No
6	119.51	73	3.3986	Yes
7	16.52	109	.5918	No

the groups of cows exhibiting the supernumerary trait and those with the normal number of teats are not significant except in the case of group 6. Although the difference found between the means of production of these subgroups of this particular sample of purebred Jersey Register of Merit cows is highly significant, there is some doubt as to whether the sample is representative of a larger sample of cows in the same breed. Since there are only eight cows with the supernumerary teats in this group and since group 2 is made up of cows of the same breed and does not show similar results such a doubt seems most logical.

When all the observations are considered, it seems that the factors for the capacity for high butterfat production are not closely linked with the character supernumerary teats. From the practical viewpoint, there is no indication that supernumeraries are external traits indicating ability superior to the normal condition for butterfat production.

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PROCEEDINGS OF THE 29TH ANNUAL MEETING OF THE AMERICAN DAIRY SCIENCE ASSOCIATION

R. R. GRAVES
Secretary

The 29th Annual Meeting of the American Dairy Science Association was held on the campus of Cornell University, at Ithaca, New York, on June 26th and 27th, and on the 28th the convention moved to the New York Agricultural Experiment Station, at Geneva, New York, for the third and last day of the conference.

At the 28th Annual Meeting at the University of Illinois last year, we recalled and discussed the organization meeting of our association at that place in the summer of 1906, and the part played by Professor W. J. Fraser in calling this meeting. The second annual meeting of what was then the "National Association of Dairy Instructors and Investigators" was called to order by President R. A. Pearson in the Record Building at Chicago, Illinois, on October 11, 1907. Eleven were present when the meeting was called to order and 21 were present at the banquet that evening.

Reports from the following committees were received and discussed:

1. Dairy score card.
2. Our relations to the National Dairy Show.
3. Courses of instruction.
4. Experimental work: Production, Manufactures.
5. Membership.

The officers elected at the meeting were:

President, R. A. Pearson (reelected).
Vice-President, Oscar Erf.
Secretary-Treasurer, C. B. Lane.

In the course of his address, President Pearson remarked:

> The name of our organization is not descriptive of its character. We call it "The National Association of Dairy Instructors and Investigators," yet some of our members represent the great dairy interests of Canada. It is then, strictly speaking, not a National Organization. The name may be criticised also, because it is cumbersome. I would like to suggest as a new name "Official Dairy Instructors' Association." . . . . . We do not want to have a poorly attended meeting annually if we can have a well attended meeting every two years. Until our work requires annual meetings I respectfully advise a meeting for business and the election of officers every two years. . . .

The Proceedings of the Third Annual Conference at Cornell University, Ithaca, New York, July 22, 1908, were as follows:

Remarks by President.
Reports of Committees:

1. Dairy Score Card.
2. Official Testing of Dairy Cows.
3. Our Relations to the National Dairy Show.
4. Courses of Instruction.
5. Experimental Work in Milk Production.
6. Experimental Work in Dairy Manufactures.
7. Standards for Dairy Products.
8. Official Methods of Testing Dairy Products.
9. Relations to Dairy Supply Houses.
10. Co-operative Work.
11. Extension Work.
12. Judging Dairy Cattle.
13. Cow test Associations.

A photograph was taken of those in attendance at this Third Annual Meeting and there were 47 men appearing in the picture. Compare this attendance with that of the 29th Annual Meeting at Cornell University where there were approximately 250 men registered. There were more than a hundred women and children came with Dad to the meeting.

At the Banquet on Wednesday evening President Stoltz asked those who were present who attended the Third Annual Meeting at Cornell University to stand. They were:

1. P. A. Campbell, then at Orono, Maine, now at Springfield, Mass.
2. H. E. Ross, then and now at Cornell University.
3. C. C. Hayden, then at Urbana, Illinois, now at Wooster, Ohio.
4. A. B. Nystrom, then at Manhattan, Kansas, now at Washington, D. C.
5. E. S. Guthrie, then and now at Cornell University.
6. J. H. Frandsen, then at Moscow, Idaho, now at Amherst, Mass.
7. O. F. Hunziker, then at Lafayette, Indiana, now at Chicago, Illinois.
8. H. C. Troy, then and now at Cornell University.

There were three others who attended the 1908 meeting who attended this year's meeting. They were:

1. H. H. Wing, then and now at Cornell University.
2. C. W. Larson, then at State College, Pa., now at Buffalo, N. Y.
3. E. S. Savage, then and now at Cornell University. (Professor Savage was in a hospital in Ithaca, with a serious illness during this year's meeting.)

At the business meeting of the association on the morning of the 26th, Dean Carl E. Ladd, of Cornell University, was introduced by Doctor Sherman. Dr. Ladd welcomed the members of the association to the campus

at Cornell University and gave an interesting discussion of the investigational work under way that bears upon the dairy industry; of the men who had been associated with Cornell University who had made history in the industry; something of the student body and other interesting phases concerning the work of the University.

R. R. Graves, Secretary-Treasurer of the association, made a brief report in which he stated that the present membership of approximately 600 members was the highest in the history of the association and was some 65 per cent higher than at the same date a year ago.

Since the minutes of the last meeting at Urbana, Illinois, were presented in full in the November Issue of the 1933 JOURNAL OF DAIRY SCIENCE the reading of the minutes were omitted.

President Stoltz appointed the following Pasture Committee to work on pasture problems:

Dr. G. Bohstedt ..... Wisconsin.
Dr. I. R. Jones ..... Oregon.
C. B. Bender ..... New Jersey.
R. B. Becker ..... Florida.
J. W. Linn ..... Kansas.
R. H. Lush ..... Louisiana.

This committee was appointed by the President of the association due to the fact that its work was of interest not only to the members of the Production Section but also to those of the Extension Section. It was explained that one representative of the American Dairy Science Association was to be appointed to work on a joint committee with members representing the Animal Production Society and the Agronomic Society. R. H. Lush, of Louisiana, was appointed to serve on this joint committee as the representative of the American Dairy Science Association.

President Stoltz announced that the annual meeting for 1935 would be held at the University of Minnesota, St. Paul, Minnesota.

Doctor Jackson, Chairman of the Nominating Committee, consisting of Ellenberger, of Vermont; Nelson, of Montana; LaMaster, of South Carolina, and Nevens, of Illinois, appointed by the President earlier in the year, gave the report of the committee.

The nominations for officers to be elected by mail votes to be sent out to the members in August, as reported by the Nominating Committee were as follows:

For Vice-President:

H. A. Ruehe, Univ. of Illinois.
E. S. Guthrie, Cornell University.

For Director for three-year term:

R. B. Becker, Univ. of Florida.
M. Mortensen, Iowa State College.

The new By-laws provide that the Vice-President of the Association shall automatically become President for 1 year following the completion of his term of office as Vice-President. Dr. C. L. Roadhouse, the present Vice-President, therefore, succeeds Professor R. B. Stoltz as President, on October 1st.

The association approved the action of the Board of Directors taken at the meeting the previous evening on the following items: (1) reappointment of Journal Management Committee for the ensuing year, 1935, consisting of Graves, Borland and Hunziker, and (2) approval of the recommendation contained in the annual report of the Sec.-Treas. to the effect that the fiscal year of the American Dairy Science Association be changed to the calendar year, balancing the books of the association as of December 31 instead of November 30 as in the past.

Doctor Dahlberg, Editor of the JOURNAL, made a brief report concerning the affairs of the JOURNAL.

President Stoltz appointed a Resolutions Committee consisting of Dr. E. C. Thompson, *Chairman*, O. E. Reed, Roger Morse, A. C. Ragsdale and W. J. Fraser.

The general program, as printed in the June issue of the JOURNAL OF DAIRY SCIENCE, then got under way.

Following the afternoon program, Professor Harrison showed groups of animals of the different breeds represented in the University herd and discussed their breeding and the plans for the future development of the herd.

The program committee had planned a recreation picnic supper at which the members and their families were to be the guests of the Dairy and Animal Husbandry Departments, for the afternoon of the first day at Taughannock Falls Park. A rather steady rain, however, made it necessary for the committee to change the scene of this picnic supper to the livestock pavilion at the University. This picnic was greatly enjoyed by the members of the association and though the scenery was missing that might have made Taughannock Falls Park very interesting, the pavilion offered very good facilities for visiting among the members. One of the events of the evening was the presentation of a scroll to Dr. O. F. Hunziker, showing the appreciation of the association of his achievements, and of his contributions to the dairy industry and to the association. Doctor Dahlberg made the presentation speech and Doctor Hunziker responded with a most interesting talk in which he recalled his student days at Cornell University. The scroll presented to Doctor Hunziker contained the following wording:

HONORED

by several national governments for his outstanding leadership in dairy research and education; recognized by his co-workers as one of the ten master minds of dairying; kindly, lovable, inspirational, ever helpful and active in our Association

OTTO FREDERICK HUNZIKER

is given this tribute at the annual meeting at Ithaca, New York, on the twenty-seventh day of June in the year one thousand nine hundred and thirty-four by the

AMERICAN DAIRY SCIENCE ASSOCIATION

R. R. GRAVES, *Secretary* R. B. STOLTZ, *President*

At the business meeting on June 27 the following report of the resolution committee was adopted:

Be it resolved that the American Dairy Science Association express their appreciation of the valuable services rendered this Association by the late Mr. K. W. Schantz, of K. W. Schantz, Inc., and convey to the members of his family our deep and sincere sympathy.

Be it resolved that the American Dairy Science Association express their appreciation of the valuable services rendered the dairy industry by the late Professor E. H. Farrington. Mindful of his many years of continuous service in systematizing scientific literature so that it could be readily understood, in translating with unusual ability the scientific results of research into plant practice, and in stimulating students of science to enter the then new field of dairying, we recognize him as one of the outstanding men of his time and extend to his wife and daughter our deep and sincere sympathy.

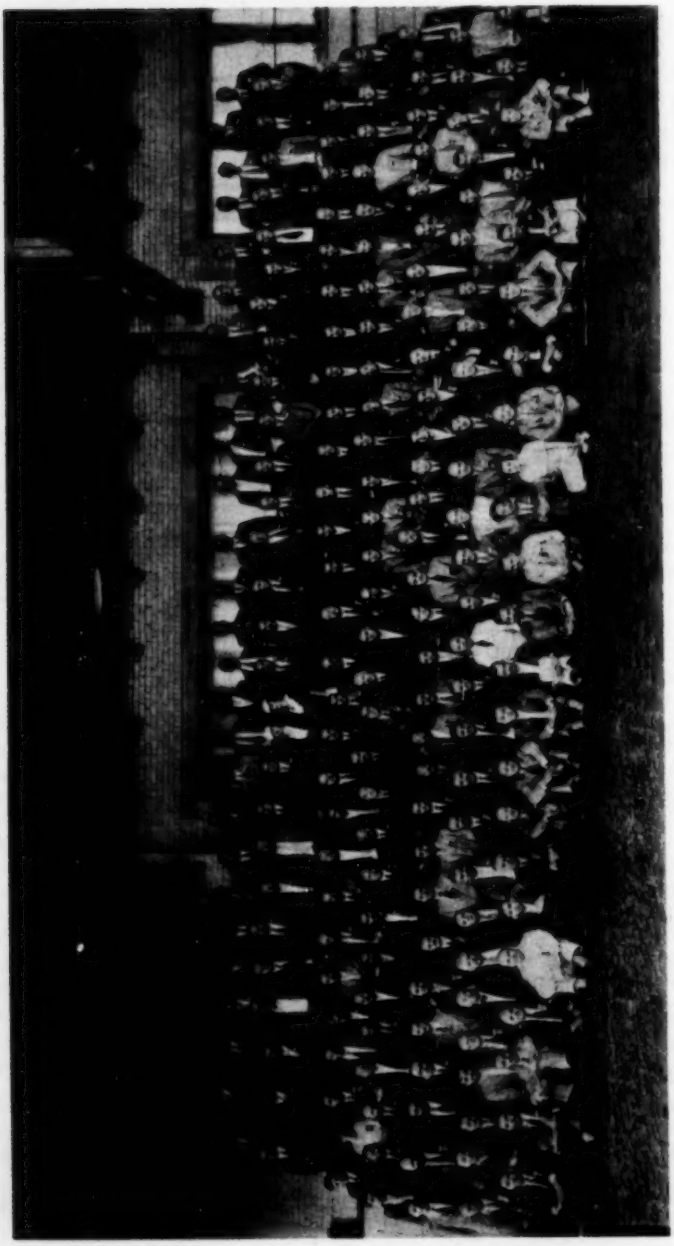
Be it resolved that the American Dairy Science Association express to Doctor E. S. Savage their sincere regret upon his inability to be with us upon this occasion and the sincere hope of a speedy recovery.

Whereas the per capita consumption of butter in this country is far below that of the leading butter producing countries of the world and this under consumption constitutes a serious problem to our industry, the permanent solution of which makes imperative the production of butter on the basis of quality, therefore: be it resolved that the American Dairy Science Association is opposed to any system or practice of production and procurement of cream and of the manufacture and distribution of butter that is known to jeopardize the quality of the finished product and we pledge our united support of and hearty cooperation with all sincere and fundamentally sound efforts on the part of the industry and regulatory authorities to combat trade practices detrimental to quality and we heartily approve the efforts of the Federal Food and Drug Administration involving the systematic and rigid inspection of all butter for purity and wholesomeness, and it is the sense of this association that the constructive and permanent improvement of the quality of cream can be made possible only by the purchase of all cream on the basis of quality.

Be it resolved that the American Dairy Science Association recognizes the importance of a great emergency and a long time agricultural adjustment program with special reference to the dairy industry and

We commend the efforts of the National Administration to develop and carry out such a program and especially the Dairy Section of the A. A. A., and the Dairy Bureau of the U. S. D. A. for their readiness to consult with and consider the viewpoint and interests of the dairy industry as a whole and,

We commend and would suggest enlargement of their educational activities relating



MEMBERS ATTENDING THE MEETING IN ITHACA ON JUNE 27, 1934

to the food value of milk and its products and in this connection their cooperation with the National Dairy Council and,

We approve and support a program for the control of diseases of dairy cattle and urge that to make it most effective and permanent an educational program to be projected either in advance of or at least concurrently with such a program to acquaint dairymen with the nature and control of the diseases included in the program.

In the case of Bang's disease, we suggest that indemnities be paid only to dairymen who sign an agreement with their State authorities to continue testing and control measures under their State accreditation rules for at least three consecutive years, and

We suggest that the secretary be authorized to send a copy of this resolution to Henry Wallace, Secretary of Agriculture, Chester Davis, of the A. A. A., and A. H. Lauterbach, chairman of the Dairy Section of the A. A. A.

Be it resolved that the American Dairy Science Association express their sincere appreciation to the College of Agriculture of Cornell University, to the Agricultural Experiment Station, to the Departments of Dairying and Animal Husbandry, to the Program Committee and to the Ladies of the Faculty as well as other individuals who have cooperated in furnishing the splendid provisions for the comfort and entertainment of all upon the occasion of the 29th Annual Meeting of the Association.

Be it resolved that the American Dairy Science Association with much appreciation commend the efforts of the Journal Management Committee and the editor of the JOURNAL OF DAIRY SCIENCE that have resulted in placing the JOURNAL on a monthly basis.

Be it resolved that the Association with much pleasure recognize the continued confidence and support given by the several advertisers in the JOURNAL OF DAIRY SCIENCE. We recognize that the JOURNAL is one of our major contributions to Dairy Science and to the Dairy Industry and on behalf of the industry we desire to express our appreciation for their loyalty and we trust that this JOURNAL will continue to merit their support.

Respectfully submitted,

O. E. REED
ROGER MORSE
A. C. RAGSDALE
W. J. FRASER
E. C. THOMPSON.

The following report of the Production Section was adopted:

The Production Section sessions have been conducted in accordance with the outlined program with every paper being given.

The business session for the section was held at the close of this morning's program. Reports were heard from the Breed Relation Committee which made recommendations concerning certain needed changes in the Herd Improvement Tests and from the Committee on Students Judging Contests. This latter committee recommended that consideration be given to the recommencing of the National Students Judging Contest in the year 1935.

The section then proceeded to the election of officers for 1935 with C. Y. Cannon, Iowa, being elected as chairman and R. H. Lush of Louisiana as secretary.

H. O. HENDERSON, *Chairman.*

The following report of the Extension Section, presented by James Linn, was adopted:

The Extension Division had a very full program, practically all of the papers being presented. A new departure, put into effect this year for the first time, was very successful. This was termed an exhibit of ideas and consisted of exhibits showing the extension activities of various States. These exhibits showed the material used in the

presentation of campaigns for increasing the consumption of dairy products, the organization of bull associations, cow testing associations, breeding schools, breeding demonstrations, etc.

The new officers elected by the Extension Service for the following year are Floyd Johnston, Iowa State College, Ames, Chairman, E. J. Perry, Jersey Experiment Station, Vice-Chairman, C. L. Blackman, Ohio State University, Secretary.

Owing to the fact that the Manufacturing Section did not have its business meeting till the last day at Geneva its report was not presented at the meeting but is presented herewith.

Dr. James Sherman, Cornell University, presented the following motion which was adopted after some discussion: "That a permanent committee be appointed to pass on honors conferred on individuals at annual meetings; that this be a standing committee consisting of the last three presidents and that the committee make its report to the Board of Directors."

President Stoltz discussed the membership drive in which he had taken an active part during the past year and presented a table showing the distribution of the membership of the association by States. The chart that was presented by President Stoltz follows:

	1933	*1934*		*1933*	*1934*
Alabama	1	1	New York	45	70
Arizona	1	7	North Carolina	1	4
Arkansas	1	1	North Dakota	3	3
California	25	36	Ohio	23	49
Colorado	2	0	Oklahoma	3	4
Connecticut	6	17	Oregon	5	9
Delaware	0	0	Pennsylvania	17	39
Florida	5	5	Rhode Island	0	0
Georgia	2	3	South Carolina	2	9
Idaho	3	2	South Dakota	1	2
Illinois	31	45	Tennessee	3	8
Indiana	15	20	Texas	4	4
Iowa	19	18	Utah	2	3
Kansas	8	10	Vermont	8	17
Kentucky	6	3	Virginia	1	4
Louisiana	2	3	Washington	5	7
Maine	2	2	Washington, D. C.	13	14
Maryland	11	15	West Virginia	7	12
Massachusetts	6	12	Wisconsin	8	23
Michigan	9	14	Wyoming	0	1
Minnesota	13	18	Canada	1	14
Mississippi	2	4	France	1	1
Missouri	12	19	Italy	0	1
Montana	2	6	Porto Rico	0	1
Nebraska	3	9	Scotland	0	1
Nevada	1	1	Denmark	0	1
New Hampshire	1	2	Holland	0	1
New Jersey	11	11	Japan	0	1
New Mexico	3	1			
				355	596

President Stoltz stated that he had recommended that the finances of the association be put on a budget basis, though no definite action was taken by the Board relative to this matter.

O. E. Reed was reappointed as a delegate to the National Research Council and Dr. L. A. Rogers was reappointed as alternate.

BOARD OF DIRECTORS MEETINGS

The following action was taken by the Board of Directors at meetings on June 26 and 27. President Stoltz presided at these meetings and they were attended by C. L. Roadhouse, Vice-President, A. C. Dahlberg, Editor, R. R. Graves, Secretary, L. A. Rogers, O. F. Hunziker and Earl Weaver, Directors.

Motion adopted that the Secretary be authorized to invest another $1500.00 in Government Bonds.

Motion adopted that the Secretary is authorized to put such additional moneys as are not needed for the current business of the association in a savings account.

The Board of Directors recommend that the Abstracts of the 1935 Annual Meeting be published by the JOURNAL in the July number; that typewritten copies of the Abstracts be submitted to the Editor by the Chairman of the Program Committee not later than the date specified by the Editor, and that a sufficient supply of page proofs be available for distribution at the Annual Meeting.

Resolved that the Editor limit all articles to 12 text pages except for articles of unusual merit.

Motion. To authorize the Secretary to secure such assistance as he may require to establish a suitable bookkeeping system for the Association, the cost not to exceed $100.00.

Moved that the finances of the Association be put on the budget system and that for the fiscal year 1935, the budget of the JOURNAL be the income from subscriptions and advertising and an additional sum to be determined by the Board of Directors and the JOURNAL Committee.

Whereas, it is the present policy of the Association to improve the JOURNAL OF DAIRY SCIENCE and increase the membership and because the Association is now engaged in the publishing business, be it resolved that it is the policy of the Association to gradually build up a reserve of $10,000 to cover such emergencies as may arise.

BANQUET

The banquet on Wednesday evening at the Willard Straight Hall on the campus of Cornell University was attended by all of the members present and the dining room was filled to capacity.

Professor G. F. Warren of Cornell University, who has been one of President Roosevelt's advisors on fiscal matters, spoke on the subject "Money" and it was apparent that his listeners were keenly interested. A mimeographed circular that contained graphs showing the rise and fall of commodity prices at various dates and with relation to certain historical events, helped in following Professor Warren's discussion of this intricate subject.

Dr. L. A. Rogers, Bureau of Dairy Industry, followed Professor Warren with an illustrated lecture on dairying in Italy. Doctor Rogers was an official delegate to the recent World's Dairy Congress at Rome. He told of the development of agriculture and particularly of the dairy industry in Italy. Doctor Rogers had taken motion pictures during his trip in Italy and these were shown to illustrate his talk.

THE MEETING AT GENEVA

Early on Wednesday morning, the 28th, those attending the meetings at Ithaca drove to Geneva. It was a bright clear morning after the rains of the two preceding days and this beautiful 45 mile drive was very enjoyable.

An address of welcome at the Geneva Experiment Station was given by Director U. P. Hedrick. Dr. Hedrick brought out the fact that a number of the men who have been prominent in teaching and research activities in the dairy industry of this country had been employed at the Geneva Experiment Station. Among these men were Babcock, Wing, Ladd, Van Slyke, Harding and Ward.

One of the features of the morning session at Geneva was the talk by Dr. R. S. Breed on the World's Dairy Congress in Rome. Dr. Breed had just returned from abroad and gave a very interesting talk on the work of the Congress.

Those attending the program at Geneva were the guests of W. L. Cherry, President of Cherry-Burrell Corporation; W. D. Pheteplace, President of Pfaudler Company, and of the Experiment Station at a box luncheon served on the lawn at the Experiment Station.

Just after the luncheon at Geneva Dr. Dahlberg had some of the sires and cows in the Station herd brought out on the lawn where he told of their breeding and production.

Following the afternoon session the members were entertained at a tea on the lawn of the home of Director and Mrs. U. P. Hedrick.

The Program Committee arranged the following program for the entertainment of the visiting ladies during the three days of the convention:

ENTERTAINMENT FOR LADIES

American Dairy Science Association
Ithaca and Geneva
1934

Tuesday, June 26 (Ithaca)

9–10 A.M.—Tour Willard Straight Hall and Sage Chapel.
10 A.M.–12:30 P.M.—Tour Cascadilla gorge, lake shore, and campus. Cars will be provided from Willard Straight Hall.

2–3:30 P.M.—Tour Martha Van Rensselaer Hall. Start from Willard Straight Hall.

3:30 P.M.—Picnic, Taughannock Falls State Park. Guests of Animal Husbandry and Dairy Departments. Meet at Dairy Building. Ladies will accompany the men. Transportation will be arranged for those without automobiles.

Wednesday, June 27 (Ithaca)

9 A.M.–1 P.M.—Tour Buttermilk Falls and Enfield State Parks. Start from Willard Straight Hall. Cars will be provided. Tour ends at Forest Home Inn.

1–2:30 P.M.—Luncheon, Forest Home Inn. Guests of Animal Husbandry and Dairy Departments.

4 P.M.—Tea at home of Professor and Mrs. Morrison, 315 Thurston Avenue. (Child care will be provided at home of Professor and Mrs. Guthrie, Forest Home. Supervised swimming, if desired.)

6:30 P.M.—Banquet, Willard Straight Hall. $1.50 per plate.

Thursday, June 28 (Geneva)

8:15 A.M.—Ladies will accompany the men to Geneva. Transportation will be arranged for those without automobiles.

10 A.M.—Leave Jordan Hall for cruise on lake.

12 noon—Luncheon with the men at Experiment Station. Guests of W. L. Cherry, President of Cherry-Burrell Corporation; W. D. Phetteplace, President of Pfaudler Company; and of Experiment Station.

1:30 P.M.—Display and demonstration of making wax models. Jordan Hall.

2 P.M.—Tour Geneva and the Shuron Optical Manufacturing Company.

3:45 P.M.—Tea for every one on the lawn at the home of Director and Mrs. Hedrick.